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A Guidebook for Low-Carbon Development at the Local Level

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Executive Summary

Local level actions and leadership are crucial for achieving national energy-saving or greenhouse gas emission (GHG) reduction targets. Local level actions can also assist in proving the effectiveness of new policies or initiatives by demonstrating them at a smaller scale. It is often also shown that innovative policies or practices can be relatively easily implemented at the local level because of the reduced scale and the possibility of exemption from some national legislative bureaucracy. Following success at the local level, the pilot policies or practices could be replicated to other localities or expanded to a national program. For example, China's Top-1000 Enterprise Program was drawn upon the successful experience from a demonstration program implemented in two steel mills in Shandong province that was modeled after the voluntary agreements program in The Netherlands (Price et al. 2003).

In developed countries, state and local level initiatives have proven to be very successful in transforming markets by engaging businesses and educating citizens. In the US, many states, cities and counties have forged ahead with dedicated funding and strategic policies to promote energy efficiency and renewable energy. California -- one of the best examples has set ambitious energy efficiency and GHG emission reduction targets and has implemented stringent, innovative policies and actions to improve energy efficiency and reduce emissions. This led California's per capita electricity consumption to be 40% less than the average per capita electricity use in the U.S. California's experiences have often been replicated or echoed in other states, and some of the policies eventually became national regulations. Many federal appliance standards today are the direct result of such state leadership (REEEP 2010). In addition, the experience also demonstrates that the adoption of a comprehensive energy and climate plan can stimulate the local economy, create green jobs in renewable energy industries, as well as produce new revenue (Roland-Holst 2008).

Even so, it is challenging to initiate and implement new policies and actions at the local level due to a lack of information, funding, and capacity. This is particularly the case in China. Even though national energy intensity and carbon intensity targets have been set, most local governments do not have the knowledge regarding what they could do to achieve these goals, the cost-effectiveness of policies, the possible impact of policies, or how to design and implement a climate action plan.

This report aims to provide a manual with a menu of the successful policies and measures for local governments in China to create low carbon plan or climate action plans. This manual includes a comprehensive list of successful policies and best practices. This report does not intend to provide independent evaluation or analysis of the GHG emission reduction or cost-effectiveness of each policy, but rather to provide the climate action plan guide and policy based on existing literature, documents and reports.

This report consists of three parts. The first section is designed as a manual to help local governments create an action plan to tackle climate change and to increase energy efficiency. It provides a simple step-by-step description of how the action plans could be established and the essential elements to be included in a plan, from preparing a GHG emission inventory to implementation of the plan. Examples from the successful network of Local Governments for Sustainability (ICLEI) are introduced, and the experience and methodology in developing local climate action plans, along with the tools developed to assist such activities, are provided as reference.

The second section of this report provides information on policies and actions to achieve low carbon growth in the following sectors: Cross-cutting (not focused on a specific end-use sector), Industry, Buildings, Transportation, Power, Agriculture and Forestry. For each policy or action identified in each sector, the following information is included, where available:

- Description
- Performance metric
- GHG emission reduction potential
- Cost-effectiveness

The policies draw on international examples, including both national and state or provincial level measures. Chinese approaches are also included if they are considered to be successful or innovative. The third section of this report is a matrix that summarizes all the successful policies and measures identified in the first section, providing users with a menu of options so that they can easily compare options and make choices sector by sector.
Key findings can be summarized as follows:

Scope and Indicators

This study focuses on carbon, and defines a Low-Carbon city as a city that is actively and significantly lowering carbon emissions, even as its economy is maturing. Therefore the report gives guidance on the reduction of the two main carbon-based GHGs: carbon dioxide (CO_2) and methane (CH_4).[1] The CO_2 emissions are primarily from energy consumption of fossil fuels, as well as from non-energy industrial processes (like cement production), and forest loss. Methane emissions arise from agriculture (especially rice production), animal husbandry, other land use, industry (e.g., coal-bed methane), and waste decomposition.

Indicators are used to define a low carbon city, to help cities explore the gaps and potential for carbon saving, to evaluate progress in implementing low-carbon development actions, and to compare or benchmark across cities. Key indicators identified in this guidance document include:

- **Aggregated** and mixed indicators, such as energy or carbon **intensity** of the economy, i.e., overall energy or CO_2 per unit GDP
- **Aggregated** relative indicators, such as energy or **CO_2 per capita** or per land area
- **Structural** indicators, such as the sectoral shares of energy and GDP
- Residential and commercial sector indicators, such as energy or CO_2 per floor area or per person; and percent compliance with **building efficiency** codes
- **Industrial** sector indicators, such as physical **efficiency** (energy or carbon per ton of product); and economic energy or carbon intensity (energy per unit value-added)
- **Power** sector indicators, such as CO_2 per kWh generated; and share of **renewables** in electricity supply
- **Transportation** sector indicators, such as primary energy or CO_2 per person-kilometer traveled; urban density; **public transit use**; and kilometers of public transit per 100,000 population
- **Land** Use and **Waste** Management indicators, such as area share of mixed–use **zoning** (residential and commercial); area share of **green space** and agricultural land; waste generated per capita; and **recycling** rate of waste.
- Economic and Social Indicators, such as share of **green jobs**; income distribution and income per capita; and **housing affordability**.

Two indicator systems have also been developed for evaluation of the performance of low carbon provinces and cities, and the evaluation of the effort taken by local government toward achieving low carbon province/city status. The Indicator System for Low Carbon Province/City Development is **sector-level, end-use based, and is measurable and comparable**. It can also be used for benchmarking and tracking progress **(**Table ES-1**).**

[1] Note that a comprehensive emissions inventory would include all *six* greenhouse gasses recognized under the Kyoto Protocol: CO_2, CH_4, N_2O (from fertilizers and manure), SF_6 (from electrical systems, magnesium production), HFCs (refrigeration, semiconductor manufacturing, aluminum smelting), and PFCs (aluminum and semiconductor production).

Table ES-1 The Indicator System Proposed for Low Carbon Province /City Development

		Essential Indicators	**Major indicators**
Aggregated indicators		• Primary energy per unit GDP • CO_2 per unit GDP • Primary energy per capita • CO_2 per capita	
LBNL low carbon city indicator		• Indexed and weighted	
	Power Sector	• CO_2 per kWh generated	• Share of renewable in electricity supply (%) • Thermal power plant efficiency (gce/kWh)
Sectoral indicators	Industrial Sector	• Final energy per unit industrial value added	• Physical efficiency (energy per ton of product) in industrial subsectors, e.g., iron & steel, cement, aluminum, ammonia.
	Commercial Sector	• Final energy per commercial floor area (recommended) • Final energy /employee	• Compliance with building efficiency codes (%) • Registered and certified LEED buildings (m^2/total m^2) • Green buildings or other certification (m^2/total m^2) • Installed capacity of integrated renewable or CHP in buildings/m^2 • Space heating intensity (MJ/m^2-HDD)
	Residential Sector	• Final energy /capita	• Compliance with building efficiency codes (%) • Registered and certified LEED buildings (m^2/total m^2) • Green buildings or other certification (m^2/total m^2) • Space heating intensity (MJ/m^2-HDD)
	Transportation Sector	• Final energy/capita	• Passenger energy or CO_2 per person-kilometer(MJ/p-km, or ton of CO_2 /p-km) • Freight final energy /ton-kilometer traveled (MJ/t-km, or ton of CO_2 /t-km) • Share of alternative fueled (hybrid, CNG, EV, NG) vehicles of the total vehicle fleet (government and private, buses, cars, trucks) (%) • Public transit use (number of public transit trips per capita) • Kilometers of public transit per 100,000 population (km/capita)
	Land Use and Waste Management	• Volume of waste disposed-landfill/capita	• Area share of mixed–use zoning (residential and commercial) (%) • Area share of green space and agricultural land (%) • Composting/capita (t/capita)

The Indicators System for Low Carbon Management could be used to evaluate the actions and effort the cities are taking /have taken to achieve a low carbon society (Table ES- 2). The local government can also use the system to identify gaps and potentials at both aggregated level and in difference sectors and take actions accordingly.

Table ES- 2 Indicator System for Low Carbon Management

Category	Description		Metrics
Planning and Management	Establish a mid-long term low carbon development plan		(Y/N)
	Complete a carbon emissions inventory		(Y/N)
	Establish a measuring and reporting system for carbon emissions for Key Energy-Consuming Enterprises		(Y/N)
Low-Carbon Energy Supply	Target	Establish energy-saving and carbon/CO_2 emission reduction targets for power sector	(Y/N) (If Y, provide target values)
		Establish target for share of renewables in electricity supply	(Y/N) (If Y, provide target value)
	Standard	Compare coal consumption for power supply between local average level to national advanced level	(provide value)
	Management	Implementation of efficiency dispatch	(Y/N)
		Punitive power pricing for energy intensive industries Differential pricing (inclining block rates) for residential electricity use	(Y/N) (Y/N)
	Demonstration	DSM, EPP demonstration projects (implementation of DSM regulation)	(Y/N)
Low Carbon Industry	Target	Establish energy-saving and carbon emission reduction targets for industry sector	(Y/N) (If Y, provide target values)
	Standard	Implementation of minimum energy use standards for 22 energy-intensive products in key enterprises	(Y/N)
		Adoption and implementation of energy efficiency reach standards	(Y/N)
		Add another one: Implementation of energy management standards (e.g. ISO 50001)	(Y/N)
		Enforcement of energy-efficiency standards for industrial equipment	(Y/N)(If Y, provide compliance rate)
	Incentive	Energy-saving incentives for enterprises (energy-saving per unit)	(Y/N) (If Y, provide value)
	Management	Implementation of energy audits	(audited plants/ total plants)
		Energy-efficiency benchmarking/compare energy use per unit and comprehensive energy use of main products to advanced levels in the same sector	(provide values)
		Energy-use reporting systems for key energy-consuming enterprises	(Y/N)
	Demonstration	Pilots/demonstration of manufacturing energy efficiency labeling programs such as Energy Efficiency Star	(Y/N)
		Pilots to introduce the use of energy managers and energy management systems	(Y/N)
Low Carbon Buildings	Target	Establish target for implementation level of residential building codes Establish target for energy consumption per m^2 of public buildings Establish target for energy use per capita in residential buildings	(Y/N) (If Y, provide target level) (Y/N) (If Y, provide target level) (Y/N) (If Y, provide target level)
	Standard	Level of energy-saving building standards	(% improvement)

		Enforcement of building energy codes	(Y/N) (If Y, provide compliance rate)
	Incentive	Incentives for green buildings/low energy buildings	(Y/N) (If Y, provide value)
		Incentives for ESCOs in building energy conservation	(Y/N) (If Y, provide value)
		Incentive to increase market share of energy-efficient appliances	(e.g., government procurement, cooperative procurement) (Y/N) (If Y, provide value)
	Demonstration	Demonstration of green, LEED, or other certified buildings	(Y/N) (If Y, provide m^2/total buildings m^2)
Low Carbon Transport	Target	Establish targets for energy-savings and GHG emissions reduction for transport sector	(Y/N) (If Y, provide target values)
		Establish target for share of public transport Establish target for share of non-motor vehicle	(Y/N) (If Y, provide target level) (Y/N) (If Y, provide target level)
		Establish target for MRT (such as BRT and railway transport)	(Y/N) (If Y, provide target level)
	Standard	Adoption and implementation of reach standard for fuel economy and GHGs emissions for newly sold vehicles	(Y/N)
		Enforcement of policy controlling for small-sized vehicles in cities	(Y/N)
		Adoption of urban planning/construction standards encouraging resource conservation and low-carbon development	(Y/N)
	Incentives	Incentives for new-energy vehicles, clean and small-sized vehicles	(Y/N)
		Incentive policies for public transport and non-motor vehicles	(Y/N)
	Demonstration	Demonstration of new energy vehicles	(Y/N)
		Dedicated transport infrastructure for city pedestrian and non-motor vehicles (e.g., bike lanes)	(Y/N)(If Y, provide km/capita)
Agriculture, Forestry and Land Use	Target	Establish target for percentage of forest coverage city green space	(Y/N) (If Y, provide target value)
		Establish target for utilization of biogas	(Y/N)(If Y, provide target level)
		Establish target for recycling rate of municipal wastes	(Y/N%)(If Y, provide target level)
		Establish target for composing rate	(Y/N%)(If Y, provide target level)
	Management	Agriculture emission reduction actions	(Y/N)
Low Carbon Technology	Demonstration projects of key low carbon technologies		(# of projects)
	Share of investment in R&D of low carbon technologies		(%)
	Incentive policies on application of low carbon technologies		(Y/N)
Supporting Measures	Carbon tax or fossil-fuel energy consumption tax		(Y/N)
	Carbon emission permit trading		(Y/N)

Creation of a Low-Carbon Development Plan

This report identifies essential steps that are commonly used in the creation of a low-carbon development plan:

1. **Leadership Commitment**
   The first essential step is commitment by the city's leadership. With the city's attention turned to low-carbon development, and sufficient staff and time and resources committed to the effort, the city can successfully develop and implement its low-carbon plan.

2. **Conduct Energy and Carbon Emissions Inventory**
   a. Identify Main Sources of Energy and Carbon
   b. Identify Options for Energy and Carbon Savings (rough analysis)

   Emission Sources. Two main carbon emission sources are carbon dioxide (CO_2) and methane (CH_4). CO_2 emissions are primarily from energy consumption of fossil fuels, as well as from non-energy industrial processes (e.g. cement production), and forest loss. Methane arises from agriculture (especially rice production), animal husbandry, other land use, industry (e.g. coal-bed methane), and waste decomposition.

   Emissions Inventory. An emissions inventory is a best estimate of emissions from activities in the city or province – not a precise measurement. The emissions inventory covers sources of carbon dioxide and methane from the following sectors: Electric Power, Industrial, Residential, Commercial, Transportation, Land Management (Agriculture and other Land Use, rural and urban), and Waste. *Scope of the Inventory*. Since some emission-generating activities may cross city boundaries, it is important to clearly define the scope of the emissions inventory, to know what emissions get counted by the city. Internationally-recognized inventory protocols have defined three emission scopes: (1) direct, (2) indirect, and (3) associated emissions. Table ES-3 explains what emissions are counted under each scope.

   Data Needs. City staff preparing the carbon emissions inventory must work with the local and provincial statistical bureau, with utilities supplying electricity to the city, with transportation and waste agencies, as well as enterprises. The basic emission sources and data needed are summarized in Table ES-4. The energy and other data on emission sources and activities, combined with emission factors, yield a GHG emissions inventory.

Table ES- 3 GHG Emissions Inventory Scope

Emissions Scope	Scope Acitivities
Scope 1: Direct Emissions: Generated Within City Boundaries	▪ Direct Energy Consumption within the City (fuel for Industry, Heating, Cooling, Electricity generation, Infrastructure, etc.) ▪ Transportation within the City ▪ Land Use and Waste Management within the City
Scope 2: Indirect Emissions: Due to Activities Within City Boundaries, Generated Outside City Boundaries	▪ Import of Electricity and Heating used in the City
Scope 3: Associated Emissions: Due to City Activities, Occuring Across or Outside City Boundaries	▪ Intra-regional Transportation ▪ City Waste in Landfills outside the City

Source: Clean Air-Cool Planet 2010.

Table ES- 4 Data Needs for a Greenhouse Gas Emissions Inventory

Sector	Data on emission sources
Electric Power	Energy mix and amount of generation: kWh from coal, natural gas, oil, hydro, wind, solar, nuclear, etc.
Industrial	Electricity and fuel (natural gas, coal, heat, others) consumption
Residential	Electricity and fuel (natural gas, coal, heat, others) consumption Building floor space and type
Commercial	Electricity and fuel (natural gas, coal, heat, others) consumption Building floor space and type
Transportation	Electricity and fuel (gasoline, diesel, others) consumption Mix of Transport Modes (feet, bicycle, motorbike, bus, light rail, train, auto, truck) Vehicle Efficiencies (Fuel Economy) for each mode Vehicle Miles Traveled (VMT) on local roads, for each mode VMT on highways (related to the jurisdiction)
Land Use	Hectares of food production, by type (rice, wheat, etc.) Numbers of cattle, pigs, horses Hectares of Forest cover (existing, removed, added)
Waste	Total landfill waste (tonnes) Typical composition of waste (organic matter, plastics and other non-degradable material, land-cover materials)

3. Set Targets

a. Forecast Energy, Carbon, and GDP under different Scenarios (Business-As-Usual, Savings Scenario)
b. Set Targets Based on Scenario Forecasts
c. If time is available, Set Targets based on detailed analysis of Potential Savings, Policies and Measures (see next step)

Target setting involves establishing the **type** of target and the target **value**. Targets need to be measurable and reportable, so that progress toward goals can be tracked. A physical target is preferable—such as CO_2 emissions, or energy use, or amount of wind energy—because it can be measured and has a direct influence on the health of the city and province. Economic targets are important, too. The target value is set by projecting energy and carbon in scenario analysis (Business-As-Usual Scenario, and Savings Scenario), and evaluating the impact of potential policies.

4. **Create a Low-Carbon Development Plan (Climate Action Plan + Low-Carbon Economic Plan), with Policies and Actions to Meet Targets**
    a. Analyze and select Policies and Actions (detailed analysis, including co-benefits, costs, and savings)
    b. Clearly state the goals for each action and how progress will be measured
    c. Choose **Policy Mechanisms** (Action Plan) to help meet targets
    d. Determine savings potential from the policies, which will depend on each province's situation (e.g., baseline inventory, mix of efficiencies in building stock, etc.)
    e. Determine costs of the measures, which will depend on each province's situation (e.g., energy pricing, renewable energy resources), as well as a typical unit cost

How can a city choose which policies it needs to meet its Target? First conduct a **rough review** of potential policies and actions, qualitatively considering estimates of savings and costs. Next, choose a shorter list of actions for **detailed**, **quantitative analysis**. Closely connect the actions to the emissions inventory and scenarios, addressing each sector of the economy. Also consider input from research institutes, the community, businesses, and government officials.

5. **Implement Policies and Actions**
    a. Identify and allocate responsibility
    b. Set aside funding for implementation
    c. Set timetables
    d. Support policies with incentives, penalties, training and public outreach

6. **Monitor, Report and Verify Progress**

    Progress must be tracked with **monitoring**, including **reporting** and **verification**. Reporting on intensity must include data on energy, data on carbon, and data on economic activity, to verify the resulting intensity number. Public reporting of data, along with progress toward goals, focuses attention and effort from government, enterprises, and the public, and helps to achieve the targets. City government websites are an effective means for publicly tracking progress on energy, carbon, and low-carbon economic development.

The guidance here focuses on the city level; similar steps can be undertaken at every level, from enterprise, to city, province, and country.

Policies and Actions to Achieve Low Carbon Growth

Because the heart of a low-carbon development plan is its actions, the guidance developed for Chinese cities also provides a menu of pertinent policy options and performance indicators. To assist local governments in prioritizing actions, the guidebook includes an estimate of each policy's potential for energy and carbon savings (the policy impact) and the relative implementation cost. Because energy and economic structures vary from city to city, the impact of the policies and associated costs also vary; each city needs to evaluate its particular circumstances in order to determine priorities and select the most cost-effective policies. Nevertheless, to assist local governments, each policy in is categorized into "High, "Medium" and "Low" in terms of potential energy and carbon savings, and in terms of implementation costs.

This guidebook includes policies and actions for low-carbon development in the following sectors: industry, buildings, transportation, power, agriculture and forestry, as well as cross-cutting policies (not focused on a specific end-use sector). Examples of such policy categories and their significance in the buildings industry, transportation, and power sectors are provided in Tables ES-5 through ES-8, and Figures ES-1 through ES-4, respectively. These tables and figures represent only a selection of the policy options examined in this guidebook. A quantitative cost-benefit analysis of policies would further facilitate policy prioritization and implementation by local governments, but such an analysis was beyond the scope of the current effort. The more detailed analysis also requires more public datasets and survey results.

Table ES- 5 Examples of Policies and Programs for Building Sector

Policy/Program Identification		Cost and Impact					
Policy Option	Performance Metric	GHGs Reduction by 2020			Cost		
		High	Med	Low	High	Med	Low
Targets							
Targets for new buildings	inspection and evaluation on compliance level both at design phase and construction phase	X					X
Targets for existing building retrofit	m^2 retrofitted	X				X	
Voluntary and negotiated agreements	target achievement		X			X	
Standards							
Building Standards		X					
National	level of the building codes; level of compliance	X					X
Leading	level of the building codes; level of compliance	X				X	
Appliance Standards							
National	level of the standard; level of compliance	X				X	
Leading	level of the standard; level of compliance	X			X		
Certification, Labels, and Voluntary Programs							
Buildings				X	X		
Categorical labels	coverage; compliance			X			X
Endorsement label	coverage; compliance		X		X		
Appliance Labels							
Categorical labels/information label	level of compliance; product grade market shift	X			X		
Voluntary endorsement label	level of compliance; product grade market shift		X		X		
Energy Management							
Energy reduction in existing buildings and quotas	coverage; compliance	X			X		
EE Technology/Measure Promotion							
Subsidies for purchase of the technology	increased investment in energy-efficient equipment	X					X
Subsidies for new building design and construction beyond codes		X				X	
Subsidies for building energy efficiency retrofit	retrofitted area	X				X	
Tax credit and other Tax incentives for EE technologies	increased sales of energy-efficient technologies	X			X		X
Setting technology dissemination goals	MW installed						
Co-operative procurement	coverage; compliance rate	X				X	

Policy/Program Identification		Cost and Impact					
Policy Option	**Performance Metric**	**GHGs Reduction by 2020**			**Cost**		
		High	**Med**	**Low**	**High**	**Med**	**Low**
Zoning							
Zoning	area coverage of zoning regulation; stringency of requirements	X					
Public Sector Leadership							
Government leadership in demonstrate new technologies or practices	coverage; compliance	X			X		X
Government procurement	whether the information is clear and accessible, compliance level (US 20%)	X				X	
Public Benefit Charges							
	total energy savings; Cost and Benefit ratios of programs/ projects funded by public benefits charge		X		X		
Building Commissioning/Auditing							
Mandatory audits	number of audits conducted	X				X	
Information Dissemination/Data Sharing							
Survey and database	website, brochures for energy consumption of the product or buildings		X			X	
Benchmarking	database establishment; accessibility of the tool or database		X				X
Awareness raising, education/information campaign				X	X		
Recognition and Awarding Policies							
	increased motivation in EE through survey		X			X	
Support for ESCOs							
	publicizing, media	X				X	
Reporting							
Detailed billing or energy consumption data and disclosure programs	data availability		X				n.a
Carbon or Energy Tax							
	tax level and coverage; variations b/w sectors		X		X		
CO_2 **Cap or Quota**							
	stringency of cap; coverage	X			X		

ES-6: Examples of Policies and Programs for Industry Sector

Policy/Program Identification		Cost and Impact					
Policy Option	Performance Metric	GHGs Reduction by 2020			COST		
		Hi	Med	Lo	Hi	Med	Lo
Targets							
Voluntary Commitments - Enterprises	average savings per participating enterprise; # of enterprises with targets; # of enterprises that meet or surpassed targets		X			X	
Voluntary Commitments - Energy-Saving and GHG Emission Reduction Sector Targets	achieved savings/emissions reductions		X			X	
Negotiated Agreements - Enterprise or Sector Level	average savings per participating enterprise; # of enterprises with targets; # of enterprises that meet or surpassed targets	X				X	
Mandatory Targets - Enterprises	average savings per participating enterprise; # of enterprises with targets; # of enterprises that meet or surpassed targets	X				X	
Standards							
Product Standards	Energy saved and/or CO_2 emissions reduced annually		X				X
System Assessment Standards	Energy saved and/or CO_2 emissions reduced annually		X				X
Process or Performance-Based Standards: Equipment Energy Efficiency Performance Standards	Cement sector reaches "advanced minimum"; Steel sector reaches "advanced minimum"	X				X	
Process or Performance-Based Standards: Small Plant Closures	final/primary energy saved per t cement; final/primary energy saved per t iron; final/primary energy saved per t steel; electricity saved per kWh; final/primary energy saved per t paper; final/primary energy saved per t aluminum		X		X		
Energy Management Standards	information on standards disseminated to industry; standards adopted		X				X
Fiscal/Financial Instruments							
Energy or CO_2 Taxes	benefit net of costs per ton CO_2 saved	X					X
Grants and Subsidies	Energy saved and/or CO_2 emissions reduced per unit of funding provided		X			X	
Energy Efficiency Loans and Innovative Funding Mechanisms	Energy saved and/or CO_2 emissions reduced per unit of funding provided		X			X	
Tax Relief	Energy saved and/or CO_2 emissions reduced		X			X	
Electricity Price Variation			X				X
Incentives/Rewards	Energy saved and/or CO_2 emissions reduced	X				X	
Energy Auditing							
Large-Scale Enterprises	# energy audits conducted; typical savings identified/audit		X			X	
Small and Medium Enterprises	# energy audits conducted; typical savings identified/audit			X			X
Benchmarking							
Enterprise Level	# enterprises undertaking benchmarking; energy saved and/or CO_2 emissions reduced as a result of benchmarking		X				X

Information Dissemination				X			X

ES-7: Example of Policies and Programs for Transport Sector

Policy/Program Identification		Cost and Impact							
Policy	**Performance Metric**	**GHGs Reduction by 2020**				**Cost**			
		Hi	Med	Lo	N/A	Hi	Med	Lo	N/A
Targets									
Target setting for transport sector	CO_2 emissions target for transport sector	X						X	
Standards									
Fuel Economy Standards	Level of standard	X					X		
CO_2 Emission Standard	CO_2 emitted per distance traveled, compliance rates	X						X	
Low Carbon Fuel Standard	% reduction in fuel carbon intensity relative to baseline		X				X		
Expand Public Transportation									
Low fares and simplified payment method	Public transit share of total transportation activity, bus loads (passengers/hour/direction), fuel economy and emission intensity of buses		X				X		
Improved route coverage and quality of service			X				X		
Rebate and subsidy programs			X			X			
Bus Rapid Transit (BRT)		X				X			
Hybrid Bus		X				X			
Urban Light Rail Transit									
Building/expanding light rail transit system	Total distance, share of total transportation activity	X				X			
Promoting Non-Motorized Transport									
Urban design to promote bicycle use (bike lanes, separate pedestrian and bike areas, bike parking options)	Share of bicycle lanes or paths of total road area, total length of pedestrian walkways, bicycling/walking as share of total transportation activity				X		X		
Pilot demonstration and rental programs for bicycles			X				X		
Urban design to promote pedestrian activity (line sidewalks with retail/benches/shading/lighting, shorten block lengths)					X		X		
Fiscal Policies									
Fuel Pricing or Taxes	Scope and coverage, level of tax	X						X	
Congestion Charges (tolls, electronic road pricing)	Reduction in traffic in target zone, modal shift to public transport, annual reduction in car mileage	X						X	
EE Technology/Behavior Measures									
Green Vehicles (Taxis, fleet cars)	Share of green vehicles in fleet		X			X			
Education and Awareness on Driving Techniques	Participants in training programs, reduction in fuel use		X			X			
Transportation Demand Reduction through Technology (telecommute, online services)	Use of online services, % employees or share of time telecommuting				X		X		

Table ES-8: Examples of Policies and Programs for Power Sector

Policy/Program Identification		Cost and Impact							
Policy	Performance Metric	GHGs Reduction by 2020				Cost			
		High	Med	Low	N/A	High	Med	Low	N/A
Targets									
Renewable and Non-Fossil Targets and Utility Quota Obligations	Installed capacity by technology, share of total installed capacity/power generation/primary or final energy consumption	X							
Economic/Financial Instruments									
Feed-in Tariffs	Level of the tariff in currency per kWh or MWh, duration of tariff, subsequent addition of renewable power to the grid				X				X
Power Purchasing Agreements	Scale of generation, contract price, length of time of contract		X					X	
Renewable Energy Certificates	Volume of RECs sold, price of RECs, number of sellers				X			X	
Generation Policies									
Mandatory closure of inefficient coal-fired plants and upgrading	Capacity closed and/or upgraded		X			X			
Generator efficiency or emission standards	Average thermal efficiency of coal-fired units, emissions intensity	X						X	
Generation Dispatch Policies	Order or basis of dispatch rule	X							X
Fiscal Incentives									
Investment subsidies					X	X			
Tax Incentives					X	X			
Investment tax incentive					X	X			
Property tax reduction	Size and use of tax incentives, capital investment in renewable energy industries, production capacity and generation output				X	X			
Value-added tax reduction					X	X			
Excise (Sales) tax reduction					X	X			
Import Duty Reduction					X	X			
Energy Production Credits					X	X			
Electricity Pricing Reform									
Inclining Block Pricing	Reduction in energy demand after implementation, level of block rates and allowable consumption under each block				X			X	
Time of Use/Critical Peak/Real-time Pricing	Reduction in electricity consumption during peak periods, peak load rate		X					X	
Demand Side Management: Energy Efficiency									

Financial incentives for modifying behavior or usage	Utility expenditures and impact on monthly utility bills, benefit-cost ratio, levelized cost, discounted payback		X			X			
Energy efficiency performance contracts					X				X
Educational campaigns					X	X			
Developing suppliers or end-use energy products and services					X				X
Demand Side Management: Incentive-Based Programs									
Load curtailment incentives	Peak demand reduction, aggregate load reduction		X						X
Curtailable or interruptible rates			X						X
Direct load control of equipment					X				X
Ancillary services programs with bidding					X				X
Capacity market programs					X				X
Demand bidding or buy-back programs					X				X

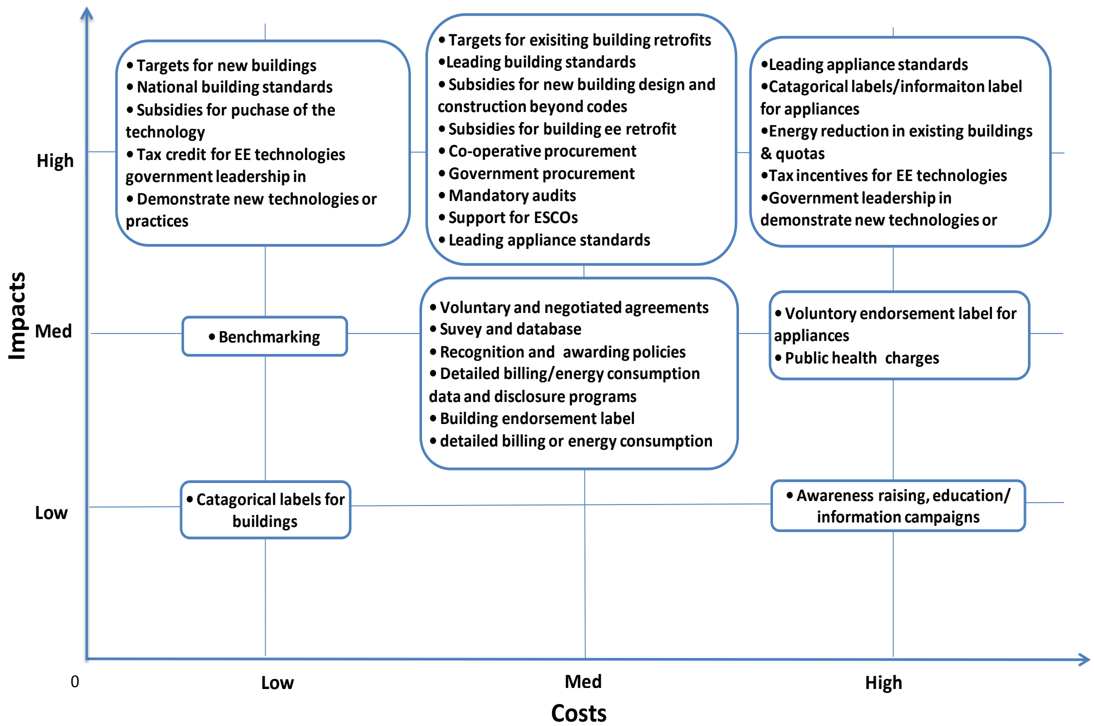

Figure ES-1 Cost and Saving of Energy Efficiency Policies in Buildings and Appliances

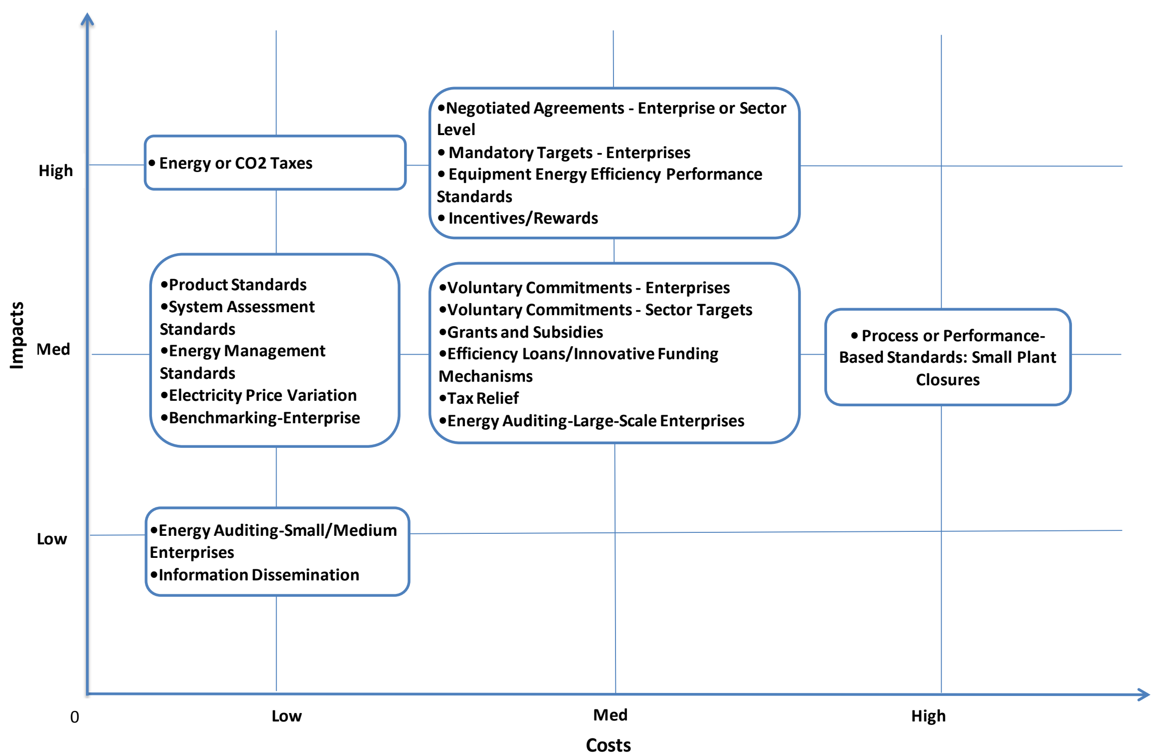

Figure ES-2 Cost and Saving of Energy Efficiency Policies in the Industry Sector

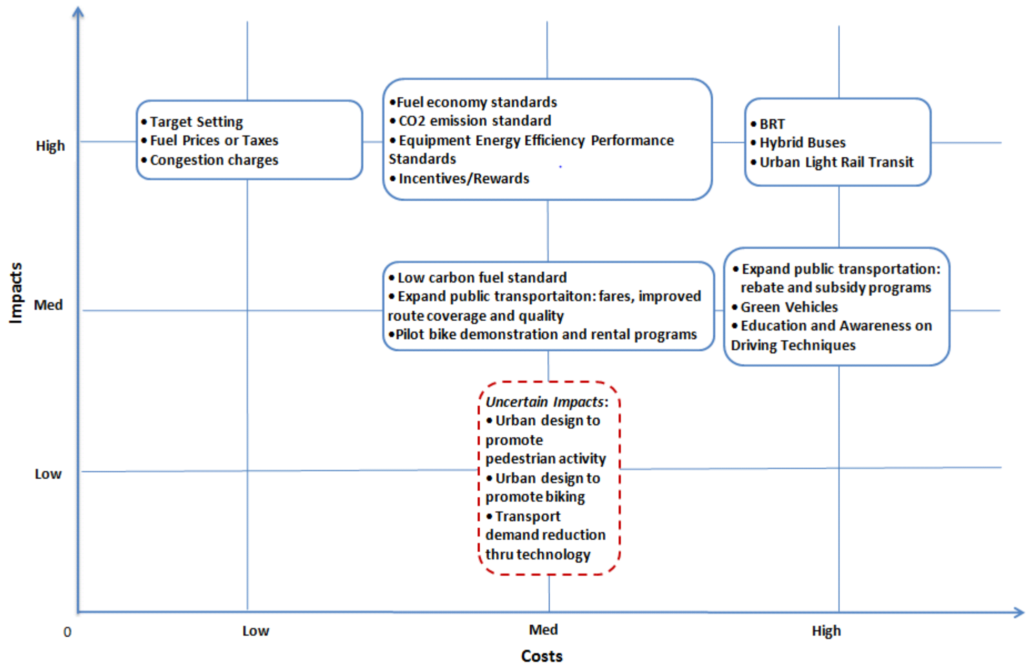

Figure ES-3 Cost and Saving of Energy Efficiency Policies in the Transport Sector

Note: Boxes with dashed red border represent policies with impacts and/or costs with uncertainties and difficult to quantify.

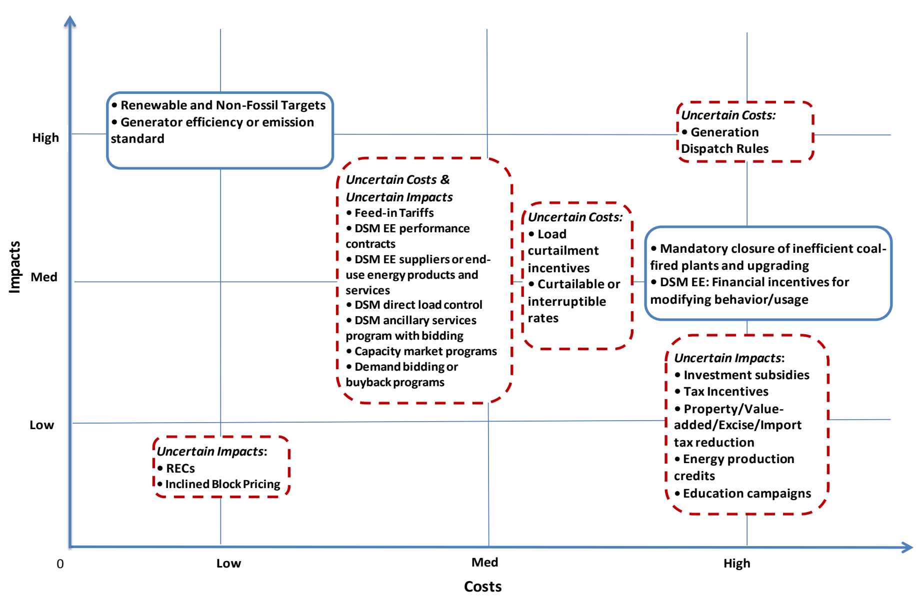

Figure ES-4 Cost and Saving of Energy Efficiency Policies in the Power Sector

Note: Boxes with dashed red border represent policies with impacts and/or costs with uncertainties and difficult to quantify.

Figure ES-5 offers another method for measuring and comparing local level actions: benchmarking. Benchmarking can be used to compare the achievements of different enterprises, cities, or provinces in response to a policy or program. For example, a program to ensure achievement of the minimum energy-intensity standards for industry could evaluate the potential savings from achievement of the standards, could identify the current efficiency levels of specific enterprises, cities or provinces, and could track progress toward reaching the standards through benchmarking. Figure ES-5 illustrates a method for comparing the level of achievement of the cement energy-intensity standards by province. Local governments can utilize the benchmarking to see their achievement in comparison with other provinces. The central government can use this type of benchmarking to identify which provinces need the most assistance in achieving the standards. The benchmarking also compares the stringency of Chinese efficiency standards to international best practices, which can inform "reach" targets for greater energy and carbon savings.

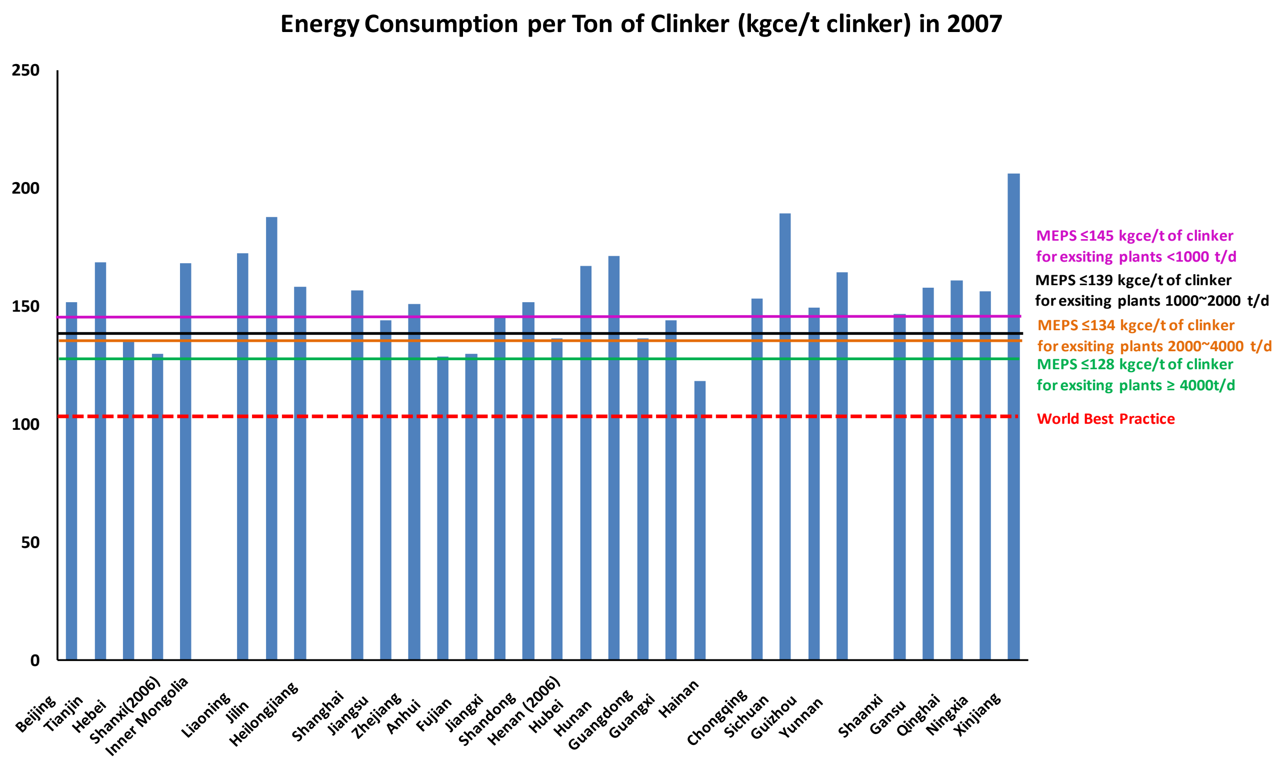

Figure ES-5: Benchmarking Energy Intensity of Cement Clinker Production in China

Two excerpts are presented below to illustrate the policy information provided in this low carbon development guidebook. The first is an example of industrial sector policy experience for energy and carbon saving: energy management standards. The second is an example for the building sector: public sector leadership. Both of these policy examples are particularly pertinent for local government in China, where energy management standards are under development and action in government buildings and facilities has not yet been tapped.

Industrial Sector Policy Example: Energy Management Standards

Policy Description

Energy management standards are used to institutionalize continuous improvement in energy efficiency within industrial facilities. These standards are typically based on the “plan-do-check-act” approach with the goal of providing guidance to industrial facility managers related to how to structure their operations in a manner that continually identifies, adopts, and documents energy-efficiency opportunities. Energy management standards have been adopted in China, Denmark, Ireland, Japan, South Korea, the Netherlands, Sweden, Thailand, and the United States. While most of these standards include key elements such as establishing a management-appointed energy coordinator and developing an energy management plan, they are not uniform in their adoption of elements such as external validation or certification of claimed energy savings or the intervals for re-evaluating performance targets (Price and McKane 2009). To provide more standardized guidance for energy management systems, the International Standardization Organization (ISO) recently published “ISO 50001: Energy management systems – Requirements with guidance for use” (Piñero 2009). This standard will:

- Assist organizations in making better use of their existing energy-consuming assets
- Offer guidance on benchmarking, measuring, documenting, and reporting energy intensity improvements and their projected impact on reductions in GHG emissions
- Create transparency and facilitate communication on the management of energy
- Promote energy management best practices and reinforce good energy management behavior
- Assist facilities in evaluating and prioritizing the use of new energy-efficient technologies
- Provide a framework for promoting energy efficiency throughout the supply chain
- Facilitate energy management improvements through GHG emission reduction projects
- Allow integration with other organization management systems (environment, health and safety).

Performance Indicator

The performance indicator for energy management standards is their level of adoption, as well as estimated efficiency improvement.

GHG Emission Reduction Potential

Participants in the Energy Agreement Programme (EAP) in Ireland are required to obtain and implement the certificate of the Irish Energy Management System IS393 to maximize energy-efficiency gains. As of 2008, 28 companies were certified with IS393. EAP member companies reported energy efficiency gains of 8% in 2007 and 6% in 2008 (SEI & LEIN 2009).

Cost-Effectiveness

Experience with implementation of energy management standards at two facilities in the U.S. indicated cost-effective savings of 5% and 14%, respectively. It is estimated that energy management standards will result in approximately 10% cost-effective annual energy savings over 15 years (McKane 2010).

Building Sector Policy Example: Public Sector Leadership

Policy Description

The public, or government, sector can play an important role in demonstrating new energy-efficient technologies or practices by setting more ambitious goals or targets for its buildings. This approach is used by local governments in the U.S. to demonstrate the feasibility and benefits of energy efficiency and renewable energy standards. States that have had difficulty implementing more stringent codes often adopt the standards for public buildings as a manageable first step. Experiences gained and lessons learned can then be shared with other building owners to promote the adoption of the codes statewide. New York City is implementing strategies to improve the energy performance of its own buildings and fleets by 30% over the next decades (REEEP et al. 2010). California's Green Building Executive Order S-20-04 also sets an ambitious 2015 goal of reducing energy use in public buildings by 20% of 2003 levels. New Mexico' Executive Order 2007-053 set a goal for all state agencies to reduce their buildings' operational energy intensity (per square foot) by 20% below the 2005 level by 2015. The U.S. also passed a law requiring new federal buildings to be designed with 30% greater efficiency than building code requirements. China's policy on Energy Management of Government Office Buildings and Large-Scale Public Buildings also calls for energy intensity reductions of 20% between 2006 and 2010 (Price et al. 2011).

Funding Sources

Funding for these types of activities comes from the government budget, grants, private foundations, utility programs and energy performance contracts.

Performance Metric

The performance metric for public sector leadership is meeting the program's stated goal or target, such as a given % reduction in energy intensity or CO_2 emissions.

GHG Emission Reduction Potential

Public sector leadership can result in high GHG emission reductions. For example, Germany achieved a 25% reduction in CO_2 emissions in the public sector over 15 years (IPCC 2007).

Cost Effectiveness

Public sector leadership can be highly cost-effective. In the U.S., it has been estimated that $4 savings are realized per $1 of public investment (IPCC 2007). The New York Municipal Building Code estimates that $2.3 billion over 9 years will be required to achieve its 1.68 million ton of emission reduction target. The cost for the upgrade of public buildings averages 1.5% of construction cost, and the energy upgrades pay for themselves on average in seven years (REEEP et al. 2010).

To date, the findings from this research have been presented in multiple workshops organized by China's central government as part of their low-carbon cities pilot project, as well as in training workshops for approximately 40 city mayors and practitioners in China. The participants were especially interested in the steps for development of a low-carbon plan and the policy matrix. As a next step, the guidebook will be piloted in cities and will be refined based on feedback received from users. Work on the indicator systems is underway and still must be reviewed by local governments; thus it is still too early to say which indicators are the most useful and relevant to local governments. Based on the feedback and experience, the guidebook can be further improved and tailored to the Chinese situation and be used by as many cities as possible in order to assist both the achievement of the carbon intensity goal and to ensure the successful implementation of the low-carbon city program.

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A Guidebook for Low-Carbon Development at the Local Level

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1. Introduction

Local level actions and leadership are crucial for achieving national energy-saving or greenhouse gas emission (GHG) reduction targets. Local level actions can also assist in proving the effectiveness of new policies or initiatives by demonstrating them at a smaller scale. It is often also shown that innovative policies or practices can be relatively easily implemented at the local level because of the reduced scale and the possibility of exemption from some national legislative bureaucracy. Following success at the local level, the pilot policies or practices could be replicated to other localities or expanded to a national program. For example, China's Top-1000 Enterprise Program was drawn upon the successful experience from a demonstration program implemented in two steel mills in Shandong province that was modeled after the voluntary agreements program in The Netherlands (Price et al. 2003).

In developed countries, state and local level initiatives have proven to be very successful in transforming markets by engaging businesses and educating citizens. In the US, many states, cities and counties have forged ahead with dedicated funding and strategic policies to promote energy efficiency and renewable energy. California -- one of the best examples has set ambitious energy efficiency and GHG emission reduction targets and has implemented stringent, innovative policies and actions to improve energy efficiency and reduce emissions. This led California's per capita electricity consumption to be 40% less than the average per capita electricity use in the U.S. California's experiences have often been replicated or echoed in other states, and some of the policies eventually became national regulations. Many federal appliance standards today are the direct result of such state leadership (REEEP 2010). In addition, the experience also demonstrates that the adoption of a comprehensive energy and climate plan can stimulate the local economy, create green jobs in renewable energy industries, as well as produce new revenue (Roland-Holst 2008).

Even so, it is challenging to initiate and implement new policies and actions at the local level due to a lack of information, funding, and capacity. This is particularly the case in China. Even though national energy intensity and carbon intensity targets have been set, most local governments do not have the knowledge regarding what they could do to achieve these goals, the cost-effectiveness of policies, the possible impact of policies, or how to design and implement a climate action plan.

This report aims to provide a manual with a menu of the successful policies and measures for local governments in China to create low carbon plan or climate action plans. This manual includes a comprehensive list of successful policies and best practices. This report does not intend to provide independent evaluation or analysis of the GHG emission reduction or cost-effectiveness of each policy, but rather to provide the climate action plan guide and policy based on existing literature, documents and reports.

This report consists of three parts. The first section is designed as a manual to help local governments create an action plan to tackle climate change and to increase energy efficiency. It provides a simple step-by-step description of how the action plans could be established and the essential elements to be included in a plan from preparing a GHG emission inventory to implementation of the plan. Examples from the successful network of Local Governments for Sustainability (ICLEI) are introduced, and the experience and methodology in developing local climate action plans, along with the tools developed to assist such activities, are provided as reference.

The second section of this report provides information on policies and actions to achieve low carbon growth in the following sectors: Cross-cutting (not focused on a specific end-use sector), Industry, Buildings, Transportation, Power, Agriculture and Forestry. For each policy or action identified in each sector, the following information is included, where available:

- Description
- Performance metric
- GHG emission reduction potential
- Cost-effectiveness

The policies draw on international examples, including both national and state or provincial level measures. Chinese approaches are also included if they are considered to be successful or innovative. The third section of this report is a matrix that summarizes all the successful policies and measures identified in the first section, providing users with a menu of options so that they can easily compare options and make choices sector by sector.

2. Scope and Indicators

China's announcement of a national carbon intensity goal in December 2009 focuses on carbon dioxide (CO_2). China also initiated a low-carbon pilot cities program in 2010. The National Development and Reform Commission (NDRC) issued a policy *Notice of Pilot Work of the Development of Low Carbon Provinces, Autonomous Regions and Low-Carbon City* in 2010 (NDRC 2010). Regarding low-carbon development in China, the Chinese government announced a policy *Notice of Piloting Low-Carbon Provinces and Low-Carbon Cities* for establishment of low-carbon cities and selected five provinces and eight cities as pilots in August 2010 (NDRC 2010). The five provinces are Guangdong, Liaoning, Hubei, Shaanxi and Yunnan; and the eight cities are Chongqing, Shenzhen, Xiamen, Hangzhou, Nanchang, Guiyang, Tianjin, and Baoding. The policy outlines the following activities:

1. Develop Low-Carbon Development Plan
2. Establish supporting policies to support low-carbon development
3. Establish low-emission industries
4. Establish GHG data collection and management systems
5. Promote low-carbon/green lifestyle and consumption model.

As more attention is being paid to low-carbon cities and in response to the goal of reducing carbon intensity by 40-45% by 2020 from the 2005 level, many other cities or counties are also following the trend toward low carbon development. However, many of these so-called "low carbon" cities are actually "high carbon" as no consistent definition, scientific scope, or indicators have been developed. Some supposedly low-carbon cities built wide roads; although lined with beautiful trees, the roads encouraged more vehicle use. Some cities excluded imported electricity from their carbon accounting. Thus, it is important to clearly define indicators, standardize the development process, and indentify policies, programs, technologies and measures that can be undertaken to realize carbon emission reductions (or carbon intensity reductions) in participating cities.

Researchers inside and outside of China have also been developing low-carbon development plans for cities in China, however, their definition, scope, indicators, and methodologies all vary significantly. Some are addressing all GHG emissions; some are focusing on sustainability that has much broader scope; some uses social development indicators to evaluate the low-carbon plans. This study focuses on carbon, and defines a "low-carbon" city as a city that has low carbon emissions.[2] Therefore the report gives guidance on the reduction of the two main carbon-based GHGs: carbon dioxide (CO_2) and methane (CH_4),[3] as they are the CO_2 emissions are primarily from energy consumption of fossil fuels, as well as from non-energy industrial processes (like cement production), and forest loss. Methane emissions arise

[2] LBNL has designed a "Low-Carbon Indicator" for use in better defining "low-carbon" that uses information on energy use in residential and commercial buildings, industry, and transport along with the carbon intensity of electricity production to rank cities and provinces (Price et al., forthcoming).

[3] Note that a comprehensive emissions inventory would include all *six* greenhouse gasses recognized under the Kyoto Protocol: CO_2, CH_4, N_2O (from fertilizers and manure), SF_6 (from electrical systems, magnesium production), HFCs (refrigeration, semiconductor manufacturing, aluminum smelting), and PFCs (aluminum and semiconductor production).

from agriculture (especially rice production), animal husbandry, other land use, industry (e.g., coal-bed methane), and waste decomposition.

Defining low carbon cities is challenging as there is not a single quantitative measurement of energy efficiency or low carbon. An engineer may define it in a restrictive sense of equipment output, whereas an environmentalist, social scientist or a politician may have a broader vision of low carbon development. We often have to rely on indicators to measure the importance of the energy efficiency and emission reduction measures. In general, the more the indicators decompose in detail, more clearly we can assess the energy efficiency and take action. Indicators help to better understand and assess how economic and technical driving factors, such as energy prices, gross domestic product (GDP) and new technologies, shape energy use and ultimately carbon dioxide (CO_2) and other emissions. Indicators can be used for: (1) historical trend analysis, (2) benchmarking, (3) designing policy and monitoring progress overtime, and (4) input to economic and technological models. This section's overall objective is to identify potential indicators that can be used to define a low carbon city, evaluate the progress and success, as well as help cities to explore the gaps and potentials.

2.1. Identification of Indicators for Low Carbon Development in China

This work began with an effort to identify indicators that have already been developed and are commonly used in benchmarking programs, inventories, and ranking systems around the world. Table 1 shows an example of the resources we have examined. The next step was to assess the availability of data needed to determine metric development priorities. Berkeley Lab also determined the relative importance of different potential categories, as well as examined the adaptability to China.

Indicators can track information at the macro-level (aggregated indicators) as well as at the disaggregated level. A macro-level indicator can give an overall sense of a city's energy efficiency, or to what extent a city is low carbon. In aggregated indicators, physical, structural and behavioral influences are not isolated. In contrast, n disaggregated sectoral level indicator can provide far more information and can serve as the foundation for future planning and actions. Figure 1 shows how detailed data and aggregated indicators can be used (Schipper et al. 1997). However, the indicators chosen also need to be based on data availability. In developing countries such as China, data availability is particularly an issue due to the lack of survey mechanisms and the lack of transparency.

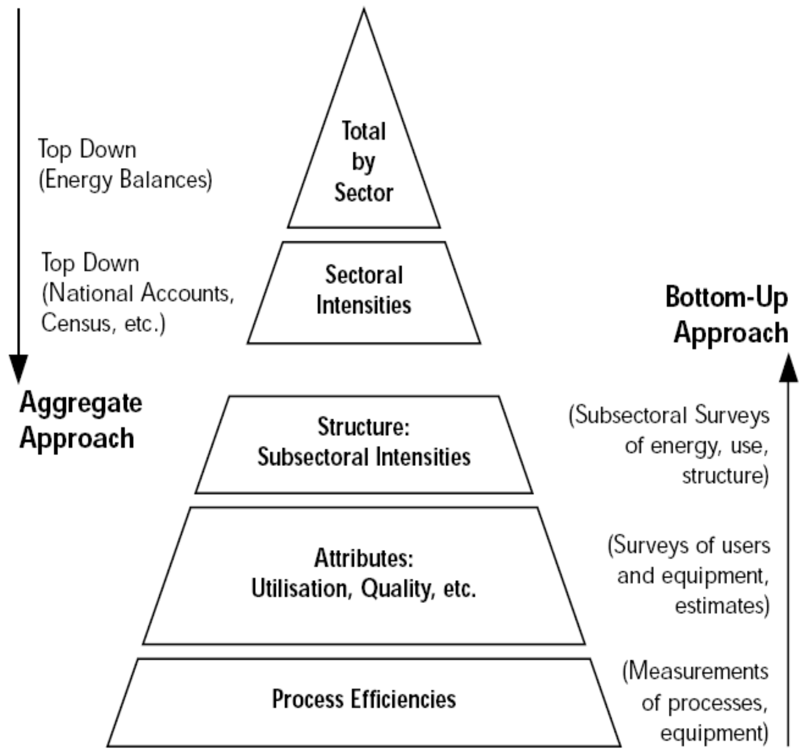

Figure 1. Energy Efficiency Indicator Pyramid

Source: Schipper et al. 1997

The main source of data for the macroeconomic indicators such as population, households, and GDP is national and local government statistics, which often includes some sectoral indicators and energy indicators as well. The energy data pertaining to energy balances come from the energy supply industries (including importers), and are often reported in the Energy Statistic Yearbooks. Tracking data on energy production is relatively simple, but trying to track the energy consumption at the end use level is a lot more challenging. Nonetheless, some of these data such as electricity use, gas use, or water use can also be collected through local utilities. Sectoral energy consumption is also available in the statistics, but it needs to be adjusted as energy used by employees in industrial companies for residential and transport purposes are accounted in the industry.

Besides statistics, representative sample surveys are often used to construct databases for indicators as they can provide details on how the energy is consumed at the end use level that energy supply data would not. Surveys are based on a scientifically selected random sample from a population. Population data are obtained by extrapolating the sample size to the total population. Often census data are used as a reliable surrogate for extrapolating survey data to national statistics. In many cases, such surveys have already been carried out at various research institutes, academia and industrial associations. However, they are very much disperse, therefore efforts in literature search and information aggregation will be necessary.

In some cases, when neither statistics nor survey results exist and effort for carrying out such work is too daunting to achieve, expert judgment maybe applied to provide reasonable estimates based on their experience and expertise in one field. However, this may lead to some uncertainties that can be estimated by giving a range of possible errors that bound the sensitivities. Nonetheless, this approach often proves to provide valid estimates as long as each step of the estimations performed are clearly described in a most transparent manner as possible.

For this study, the following criteria have been used to identify the indicators that are recommended for use in evaluating low carbon city development:

- Importance to carbon emission reduction
- Data availability
- Data that should/could be gathered and tracked
- Indicator could be ranked or assessed
- Possible interpretations and actions following from each indicator.

China has committed to energy intensity targets for its Five Year Plans and a carbon intensity target for 2020, and these targets are being disaggregated to provinces, cities and counties. However, the targets need to be further disaggregated by sector at the local level to evaluate the potentials, to develop specific action plans, and to track trends in GHG emissions or energy consumption. These metrics, which are designed to measure improvements in CO_2 intensity or energy efficiency independent of economic growth or growth in production, use either an economic or a physical value for the denominator. For example, the energy intensity of cement production can be measured as energy use per dollar of value added by the cement industry (economic metric) or energy use per ton of cement produced (physical metric).

Economic metrics are typically used when aggregating across heterogeneous entities that do not produce comparable products (e.g. the entire manufacturing sector). Physical metrics are typically used to compare entities that have similar production outputs. Recent analyses have shown that there is great variability such as structural and activity effect in economic metrics and that metrics based on physical values more accurately trace actual trends in emissions or energy intensity, although the heterogeneity of the industrial sector can make development of such metrics difficult for some industries (Freeman et al. 1996; Worrell et al. 1997). As a result, there have been increasing efforts to develop suitable physical metrics (Farla 2000; LBNL 1999; Nyboer and Laurin 2001a; Nyboer and Laurin 2001b; Phylipsen et al. 1996; Phylipsen et al. 1998). For example, in transportation sector, a disaggregated indictor can enable the analysis on how size and weight of the vehicles can cause the increase in energy and emission increase while the efficiency of the vehicles continue to improve.

The following indicators both at aggregated level and sectoral level have been proposed as options for the low carbon city development in China.

Aggregated:

- ***Energy or CO_2/GDP***

  The ratio of energy consumption, or carbon emissions, to gross domestic product (GDP) is used to measure the economic energy intensity of national economies. This is a dominant indicator used in China's 11th and 12th Five-Year Plans and announced internationally. An intensity indicator is appealing at the aggregate level, as it utilizes sets of data already tracked: energy, carbon, and GDP. However, this is a mixed indicator, accounting for both physical energy efficiency and economic structure that influences energy consumption. As economic development proceeds, the economic energy intensity typically declines yet absolute energy and carbon still increase. Thus there are significant limitations to this indicator and its use in target setting. Indicators distinctly focused on the physical energy and carbon intensity of the economy, and on aspects of economic structure that affect energy consumption and carbon emissions, are encouraged instead.

- ***Energy or CO2/capita***

  Because energy consumption and carbon emissions can be strongly influenced by the size of the population, per capita indicators provide a better and more equitable basis for comparison across cities, provinces, and countries. This indicator is widely used in China and internationally. Highly aggregated per capita indicators, such as total energy or CO_2 per person, should still be used with caution, however. A city with heavy industry and small population, which supplies other cities with cement and steel, would have high energy per capita. Yet the people of the city might use relatively little energy in their residences. Thus it is important to consider *residential* energy per capita, and the *energy structure* of a city, as well as total energy or CO_2 per capita.

- ***Energy or CO2/land area***

  Another measure of the energy or carbon intensity of a city can be a spatial measure, a density, per land area. This indicator is less common, but is being examined as cities consider how density of development influences energy consumption and carbon emissions.

- ***Economic Structure: sectoral shares of GDP (primary, secondary, tertiary)***

  Because different sectors of the economy have notably different energy and carbon intensity, economic structure is an important indicator of structural influences on consumption and emissions. Of many definitions of economic structure, the simplest and most often used in China is the share of primary, secondary, and tertiary sectors of the economy. The secondary sector represents industry and construction – the most energy intensive—while the tertiary sector represents commerce and service-focused businesses such as Information Technology (IT), communication services, health care, and energy saving services. Even this fairly aggregated indicator can help cities identify areas for low-carbon development.

- ***Energy Structure: sectoral shares of energy consumption—industrial, residential, transport, other***

  Similar to an economic structure indicator, energy structure helps to identify areas needing extra attention for low-carbon development. Typical definitions of energy sectors include: industrial, residential, transport, agriculture and forestry, commercial, construction, etc. The first three sectors are the easiest to obtain data on; often the remaining energy sectors are grouped into "other energy." The industrial energy sector coincides with the secondary economic sector, while the others have overlap to different extents.

- ***Industrial energy or CO2/ industrial value-added GDP***

  The economic energy intensity of industry—industrial energy per unit of industrial value-added economic output—is a key indicator in China's 11th and 12th Five-Year Plans. Industrial carbon intensity is a similar type of indicator, but differentiates among the energy sources utilized by industry. This is a highly aggregated indicator, and it can help cities compare their industrial intensities and track them over time. However, it doesn't offer specific ideas for saving energy and reducing carbon. In addition, different pricing or differences in local economies can muddle the meaning of this indicator.

- ***City greenhouse gas emission inventory***

  The first step toward low-carbon development for a city is an inventory of the city's carbon (greenhouse gas) emissions. Of great importance, a carbon inventory tracks *absolute amounts* of greenhouse gas emissions, whereas many other indicators only track ratios. The inventory is derived mainly from a city's energy statistics, including the fuel mix and sources of electricity. Thus a carbon inventory goes hand-in-hand with tracking absolute amounts of energy consumption. A city must have completed a carbon inventory to begin the path toward low-carbon development, and to wisely choose measures to save energy and reduce carbon, while encouraging a thriving local economy.

- ***Overall renewable energy use, and share of renewables in total city energy***

  A key indicator of the carbon intensity of a city is the amount of renewable energy in the mix. Renewable energy includes wind, solar thermal (for hot water), solar photovoltaic (for electricity), hydropower (with a distinction between large and small hydro), geothermal, and biomass. (Nuclear energy, although low carbon in operation, is not a renewable energy source.) This overall renewable energy indicator captures renewables that provide heat and transportation, as well as electricity. It is a well-defined indicator and helps a city clearly track progress toward low-carbon energy supply.

- ***City staff and city budget devoted to low-carbon planning and implementation, and their share of total staff and budget***

  Real progress on any policy initiative requires staff time and budget. One indicator of progress toward low-carbon development is the designation of staff and budget toward planning and implementation. In addition to numbers of staff, cities should strive to find the most qualified personnel possible and look for training opportunities for existing staff.

Residential Buildings:

- ***Residential energy consumption or CO2 emissions/capita (could be climate adjusted) (ICLEI, IEA).***

  In developed countries, the growth in per household floor space is one of the major drivers explaining increase in energy consumption. This indicator is commonly used to capture the energy efficiency of the building and the home appliances, as well as behaviors. If possible, it should be climate adjusted to exclude the influence on energy use induced by different climate, and could thus be compared with other peer cities. For instance, comparing the residential energy intensity in severely cold zone such as Harbin with a mild weathered city such as Kunming will not be fair otherwise. And a lower energy consumption number doesn't necessarily implies the high energy efficiency without taking the weather into consideration.

  Weather variation can be accounted by calculating cooling degree-days (CDD) and heating degree-days (HDD). HDDs and CDDs are measures of how cold/warm a location is over a period of time relative to a base temperature, most commonly specified as 18 °C. Heating degree days are summations of negative differences between the mean daily temperature and the 18 °C base; while cooling degree days are summations of positive differences.
  Energy data could be obtained through the city statistics with adjustment to include residences in an industrial unit, and the transportation energy consumption needs to be taken out (e.g., gasoline, and some diesel.), population data are available in the cities statistics.

- ***Residential energy consumption or CO2 emissions/m2 (could be climate adjusted) (ICLEI, IEA)***

  This indicator is similar to the per capita based intensity, but targets the building energy efficiency based on the households without considering the number of people living in one house. In addition, it may favor big houses. Floorspace data are available in the statistics in the form of m2 per capita in urban area and rural areas.

- ***Registered and certified LEED buildings, green buildings or other certification/capita***

  LEED buildings or Green buildings are practices aimed to increase efficiency with which buildings use resources, energy, water and materials through better sitting, design, construction, operation, and removal. More numbers of such certified buildings in a city would imply lower energy and lower emission. However, the selection of the certification/label scheme should be well evaluated as in practice, a well certified building could use more energy compared than a similar building without it. 28-35% of LEED buildings used more energy than their conventional counterparts. And research also shows that the measured energy performance of LEED buildings had little correlation with certification level of the building, or the number of energy credits achieved by the building at design time. Therefore types of certificate should be carefully assessed and the selection should be based on the verified actual savings that a certified building could deliver through measurement or tracking the change in utility bills.

- ***Building codes compliance in percentage at the construction phase***

  Building codes need to be enforced to keep the integrity of the standard as well as ensuring energy savings. The compliance could be checked the tracked. The MOHURD conduct random checking on compliance rate at each province, and three cities at different level in the province. Local government such as the building construction commission and planning bureau all carry out inspection on both paper documents as well as onsite inspections. So the data should be available.

- ***Installed capacity of integrated renewable in buildings/m2 (PV, solar water heaters, geothermal)***

  This indicator could demonstrate the cities' actions in reducing carbon emissions in buildings, not necessarily improving the efficiency of the buildings. Therefore should be used in conjunction with other building efficiency measures that aims to reduce demand.
  By using the per m^2 base, the indicator can avoid the tendency for favoring large buildings and large cities.

Commercial

- ***Commercial energy consumption or CO2 emissions/m2 (could be climate adjusted) (ICLEI, IEA, Canada – Voluntary Challenge Registry)***

  This indicator is commonly used for evaluating whether a commercial building is low energy and low carbon buildings. Same as the residential buildings, climate adjusted intensity would reflect the real energy efficiency without being interfered by the various climate conditions among cities. Commercial and industrial floor space data maybe sometime collected through the taxation local office through properties taxes. Or the building construction commission or the Planning bureau often has the record of the construction area. If data are available broken out by types of buildings, then more detailed information and comparison could be provided as the energy consumption pattern are very different among different building types such as retail, office, hotel, education, health care, and other.

- ***Total primary energy per unit of service sector GDP(could be climate adjusted).(IEA, European Commission Energy Efficiency Indicators Project)***

  This indicator can be used to observe how service energy use on a per value of output produced, measured in local or international currency and in real terms, is evolving. However, little can be said on the drivers of the trends that can be observed, and it does not distinguish the different effects that influence energy consumption and is a poor indicator of energy efficiency. Cross-country comparison is limited by the fact that value of goods varies across cities.

- ***Energy/ electricity consumption per employee (IEA, European Commission Energy Efficiency Indicators Project, Canada – Voluntary Challenge Registry)***

  Besides the intensity in terms of energy use per unit of service floor space stated above, an alternative will be the energy use per employee in the sector. Data on employee numbers may be easier to collect than m2 which provide the advantage for the use of this indicator. However, per square meter is slightly more meaningful as energy use is generally used at the level of floor space

- ***Space heating energy consumption per square meter(could be climate adjusted), (IEA)***

  Significant proportion of energy use in commercial buildings is in space heating and cooling. In countries or regions where the climate significantly influences energy use, energy consumption needs to be adjusted to take account of degree days.

- ***Registered and certified LEED buildings, green buildings or other certification/capita***

  Same as in residential sector

- ***Building codes compliance***

  Same as in residential sector

- ***Installed capacity of integrated renewable in buildings/m2 (PV, solar water heaters, geothermal)***

  Same as in residential sector

- ***Installed capacity of CHP in buildings***

  Commercial buildings represent the fastest growing segment of electricity demand, and their share of total consumption is projected to steadily increase. Also, because commercial building electricity use is coincident with total system load, its growth is a major driver of peak load growth and the consequent requirement for new capacity additions. For the same reason, electricity used by the commercial sector is disproportionately derived from thermal sources, making the carbon footprint of the sector greater than its share of electrical energy consumption might suggest. At the same time, there are strong differences of professional opinion about the best approach to constraining the carbon emissions consequences of this commercial sector load growth, with many analysts suggesting that efficient end use equipment will yield the best results, while others say that on-site generation with recovery of waste heat will be most effective. Particularly it will be very effective to the fast growing city center where the expansion of existing centralized grid reaches its limit due to the already congested infrastructure.

Industry

- ***Share of coal in industrial fuel mix***

  This indicates the extent to which lower carbon fuels, such as natural gas or biomass, are used by industrial facilities. Some industries, like cement, can replace the use of coal in the kiln with natural gas and many other alternative fuels including agricultural and non-agricultural biomass (sewage sludge, paper sludge, waste paper).

- ***Industrial economic energy or carbon intensity***

  This indicator is often used at a highly aggregated level, combining all industrial energy consumption (and carbon emission) with the value-added economic output from industrial activities (see above). This indicator can also be used at a sub-sectoral level, for example, helping to compare the intensity of overall cement production in a city, with the intensity of chemical or steel or other industrial sub-sectors. `This can help a city identify development to promote or restrict, and help benchmark with other cities.

- ***Enterprise-level Resource productivity***

  - Manufacturing energy use per unit of manufacturing value added GDP
  - Sales/CO_2 emissions
  - Production volume/CO_2 emissions
  - Productivity efficiency ratios measure the outputs of an enterprise in relation to their carbon emissions impacts. Sales/CO_2 emissions measure resource productivity, and production volume/CO_2 emissions measures process eco-efficiency.

- ***Physical energy or carbon intensity of key products produced***

  Physical energy or carbon intensity (vs. economic energy or carbon intensity using value added as the denominator) is preferred because it is a more robust indicator of the level of energy or carbon efficiency of the production process.

- ***Energy use or carbon emissions/t crude steel***

This indicator captures the effect of both the share of enterprises with electric arc furnaces (which are less energy and carbon intensive) vs. those with basic oxygen furnaces (which are more energy and carbon intensive) as well as the overall energy or carbon intensity of both processes.

- ***Energy use or carbon emissions/t cement***

  This indicator captures the effect of both the share of enterprises with rotary kilns (which are less energy and carbon intensive) vs. those with vertical shaft kilns (which are typically more energy and carbon intensive) as well as the overall energy or carbon intensity of both processes. If there is a significant amount of clinker imported or exported, then the denominator for this indicator should be clinker if data on clinker-related energy consumption or carbon emissions are available (or a correction should be made to account for clinker trade).

- ***Energy use or carbon emissions/t aluminium or electricity use/t aluminium***

  This indicator captures the effect of both the share of enterprises with secondary (recycled) aluminum production (which is less energy and carbon intensive) vs. those with primary aluminum production (which is more energy and carbon intensive) as well as the overall energy or carbon intensity of both processes.

- ***Energy use or carbon emissions/t ammonia***

  This indicator captures the effect of both the type of feedstock used (coal – which is more energy and carbon intensive or natural gas with steam reforming – which is less energy and carbon intensive) as well as the overall energy and carbon intensity of the production process.

- ***Energy use or carbon emissions/t ethylene***

- ***Energy use or carbon emissions/t caustic soda***

- ***CO2 emissions per unit of manufacturing energy use and CO2 emissions per unit of manufacturing GDP (IEA)***

  Since the manufacturing sector is extremely diverse, IEA relies more heavily on economic indicators such as energy use per unit value added, to be able to compare trends across manufacturing sub-sectors.

Power

- ***CO2 emissions per terawatt hours (TWh) generated (Canada – Voluntary Challenge Registry, Australia – Greenhouse Challenge)***

  The amount of CO_2 equivalent emissions per unit of generated electricity is a common indicator for tracking de-carbonization of electricity supply. Expressed as tCO_2eq/kWh or tCO_2eq/TWh, this indicator helps to track the reduction of carbon-intensive coal, and the fostering of renewable power generation, as well as generation from natural gas and nuclear. This indicator also serves as an emission factor for determining carbon emissions from electricity use.

- ***Share of renewable sources in electricity supply; GW of operating renewable capacity***

  The share of renewables in electricity supply is an indicator often used to track progress with Renewable Portfolio Standards (RPS). While the CO_2eq/TWh is an indicator of net carbon in electricity, the share of renewables highlights the most sustainable energy sources. As the absolute amount of energy consumption changes, it is also useful to track the absolute amount of renewable generation capacity that is installed and actually operating. Wind farms can't reduce carbon emissions if they aren't sending power to the grid, so it's important to know and count the operational status of renewables.

Land Use and Waste Management

- ***Waste per capita (disposed, diverted)***

  The amount of waste per person is an indicator of the resourcefulness of the city's people; less waste means more efficient use of resources. Waste contains embodied energy and carbon, materials, and pollutants. By reducing the amount of waste generated—and disposed—per person, a city can save resources. Reducing the amount of waste going to landfill also reduces emissions of methane (a potent greenhouse gas) from the decomposition of organic waste in landfills.

- ***Recycling, and overall diversion rate, of waste away from landfills***

  For any waste that is generated, there is still the possibility of recycling, composting, or otherwise diverting the waste from disposal. For most wastes, there is a net energy and carbon saving from recovering the waste. Tracking the recycling and/or diversion rate is a widely used indicator at the city and enterprise level.

- ***Percentage of landfill gas (methane) that is captured***

  For any waste that does end up in a landfill, there is one last option for recovering energy and reducing carbon emissions: landfill gas capture. Landfill gas is primarily methane; thus it can be captured to avoid methane emissions, and also utilized as a fuel, thereby replacing the use of a more carbon-intensive fuel such as coal.

- ***Mixed-Use (Residential + Commercial) Zoning – area, and share of total***

  One of the key drivers of transportation fuel use and vehicle miles traveled is the land development pattern of a city. Numerous studies have linked mixed-use zoning with lower energy and carbon in transportation (Newman and Kenworthy). Mixed-use zoning combines residential and commercial uses in clusters (urban villages) that are well-connected to public transportation. Mixed-use zoning can also influence the types of residential and commercial buildings that are developed, along with their energy use.

- ***Agricultural Land - Hectares of food production, and share of agriculture in total area***

  The amount of agricultural production within city (or county) boundaries is important to low-carbon development for two main reasons. The first is that local food production can lower energy and carbon, by reducing transport and refrigeration needed to provide food for the city. The second is that some types of agricultural production, notably rice production, can generate methane emissions; management practices can be used to reduce those emissions. Other types of food production provide short-term sequestration of carbon. An important added benefit to local food production is that it supports local farmers, provides jobs, and better connects urban dwellers to the source of their food.

- ***Green Space / Open Space – area, and share of total***

  The amount of green space (or open space) in a city is a common overall indicator of sustainability and livability. Indirectly, the amount of green space can reduce the urban heat-island effect, thereby reducing building energy consumption. Green space also encourages pedestrians and cyclists, thereby reducing transportation energy and carbon.

- ***Industrial Zoning – area, and share of total***

  Because industry has the highest energy and carbon intensity among a city's economic activities and land uses, tracking the share of land in industrial use is an important indicator. As the government emphasizes structural shifts in the economy, away from heavy industry and toward the service sector, cities can strive to designate more land for non-industrial purposes. Over time, cities can develop means of gathering revenue from non-industrial land uses, to encourage the shift away from industry.

- ***Trees and Forest: Hectares of Forest cover (existing, removed, added), share of total area; number of trees planted in urban areas***

  Forested areas and even smaller stands of urban trees can sequester carbon, provide shade and cooling for buildings and people, and generally create a more livable city. In a carbon inventory, adding forested areas can be counted as carbon savings or offsets. Forested and other green areas also maintain soil health, reduce erosion, and offer habitat.

- ***Numbers of cattle, pigs, horses (to track methane)***

  Locally-raised animals can be an important source of food and labor. However, the digestive system and waste of ruminants (cattle, pigs, goats, horses) releases methane, a potent greenhouse gas. The city's carbon inventory should count those emissions. Because cows release the highest amount of methane, recommendations for low-carbon development include encouraging less consumption of beef and dairy products, and greater consumption of vegetables, legumes, and high-protein grains.

Transport

- ***Primary energy or CO2/ vehicle-km (IEA, ICLEI)***

  This indicator provides a measure of the average fleet efficiency of all vehicles in a city. Calculating this indicator requires knowing the total trip length of all public transportation modes (subway, bus, street cars) in addition to total trip length of all private transport (cars and taxis), as well as the total trip length of all trucks (light, medium, and heavy duty), as well as the total energy consumption of these vehicles. It could alternatively be estimated from a calculation of the average fleet efficiency (by vehicle type) in MJ/km along with the annual vehicle kilometers travelled by vehicle type.

- ***Primary energy or CO2/ person-km***

  This indicator provides a measure of the energy or carbon intensity of moving people around a city. Calculating this indicator is challenging, since it requires knowing the turnover (passenger-kilometers) of all public transportation modes (buses, light rail, subway, etc), and estimating the total person-trip-kilometers for all private travel in cars and taxis, as well as the total energy consumption of these travel modes.

- ***Primary energy or CO2/ ton-km***

  This indicator provides a measure of the energy or carbon intensity of moving goods to and around a city. Calculating this indicator is challenging since it requires knowing the total freight turnover of a city (in ton-km) and the energy consumption of the vehicles used for freight delivery.

- ***Kilometers of high capacity public transit systems per 100,000 population (Global City Indicators)***

High capacity public transit (such as BRT) facilitates movement of large numbers of people typical of morning and evening commute hours. The more extensive the system, the higher likelihood that commuters will choose this mode of travel over less efficient modes

- ***City resident public transit use (number of public transit trips per capita)***

  The degree to which residents choose to ride public transportation in their total annual travel reflects both the accessibility and desirability of public transportation as well as results in lower transportation energy consumption and road congestion compared to use of personal cars. Data on total kilometers of travel in personal cars are generally not available, but surveys can provide a baseline of total personal travel by mode.

- ***Urban density***

  Higher density land use is strongly correlated with lower energy and resource consumption. For transportation, higher density allows for greater access to public transportation, reduces transit network length, and reduces the need for private cars. Urban density can be measured in terms of population per square kilometer, excluding parks and designated open space; as the number of dwelling units per square kilometer; or as a floor area ratio of the total floor area of buildings divided by the total land area used.

- ***Share of each city's alternative fueled (hybrid, CNG, EV, NG) vehicles of the total vehicle fleet (government and private, buses, cars, trucks)***

  City governments often own and operate a fleet of vehicles, including cars, trucks, buses, and specialized vehicles, running on gasoline and diesel. This indicator measures the number of these vehicles that run on alternative fuels with lower emissions than standard internal combustion engines.

- ***Two-wheeled vehicle ownership per capita***

  Two-wheeled vehicles, including conventional bicycles, e-bikes, and motorcycles, offer some of the highest energy efficiencies of urban transportation modes. Registration data should be available for motorcycles and e-bikes.

- ***Km of bike lanes***

  Dedicated bike lines provides additional safety and incentive to use bicycles for urban travel, offsetting usage of personal cars.

Economic and Social Indicators

Several economic and social indicators are often tracked at the city level, to connect low-carbon development initiatives with city-level economic and social goals. When done well, low-carbon development can help to provide jobs and improve living conditions. As many Chinese cities take on the challenge of shifting to lower-energy economic activity, tracking these indicators will be helpful.

- ***Population***
- ***GDP per capita***
- ***Income per capita***
- ***Distribution of income***
- ***Share of population in poverty***
- ***Housing affordability***
- ***Employment, overall***
- ***Employment in "green" sectors, especially energy and carbon saving***

Table 1. Sector-Specific Metrics commonly Used for Commercial Buildings, Transportation, Industry, and Power

INTERNATIONAL	Commercial Buildings	Transportation	Industry	Power
Greenhouse Gas Protocol Initiative **(GHGPI 2001)**	• Sales/GHG emissions		• Production volume/GHG emissions • GHG emissions/function or service	• Tonnes of CO_2/electricity unit generated
UNEP GHG Indicator **(Thomas et al. 2000)**	• GHG emissions/unit of sales • GHG emissions/unit of value added • GHG emissions/number of employees		• GHG emissions/unit of value added • GHG emissions/ unit of production	
International Council for Local Environmental Initiatives (ICLEI) **(ICLEI 2001)**	• Energy use/operating hours • Energy use/occupants • Energy use/floor space • Energy /commercial establishments • CO_2 eq. Emissions/operating hours • CO_2 eq. Emissions/occupants • CO_2 eq emissions/floor space • CO_2 eq. Emissions/commercial establishments	• Energy/vehicle kms traveled • Energy/vehicle • CO_2 eq emissions/ vehicle kms traveled • CO_2 eq emissions/vehicle	• Energy/floor area • Energy/industrial employees • Energy/industrial establishments • CO_2 eq. Emissions/floor area • CO_2 eq. Emissions/industrial employees • CO_2 eq. Emissions/industrial establishments	
International Energy Agency **(IEA, 1997)**	• Space heating energy use/square meter floor area • Electricity use/capita • Electricity use/unit of floor area • Electricity use/unit of service sector GDP • Electricity use/employee • Total primary energy/unit of service sector GDP • CO_2 emissions/capita • CO_2 emissions/unit of services GDP	• Energy use/passenger km • Travel-related energy use/total national GDP • Tonnes of CO_2/capita • Energy use/tonne-km of freight • Freight-related energy use/total national GDP • Freight CO_2 emissions/capita	• Energy use/tonne product • Energy use/$ value added • CO_2 emissions/unit of manufacturing energy use • CO_2 emissions/unit of manufacturing GDP	
European Commission Energy Efficiency Indicators Project **(ODYSSEE 2001)**	• Energy/value added • Energy/employee • Energy/floor area	• Freight energy/tonne km • Passenger energy/person km	• Energy/value added • Energy/tonne for energy-intensive industries	
International Network for Energy Demand Analysis in the Industrial Sector **(LBNL, 1999)**			• Energy use/tonne product • CO_2 emissions/tonne of product	

NATIONAL	Commercial Buildings	Transportation	Industry	Power
Australia – Greenhouse Challenge **(AGO 2001)**	• CO_2 emissions/surface area • CO_2 emissions/transactions		• CO_2/tonne of product	• CO_2 emissions/kWh
Canada – Voluntary Challenge and Registry, Inc. **(VCR-MRV, Inc. 1999)**	• GHG emissions/total building area • GHG emissions/heated building area • GHG emissions/number of occupants or employees • Energy/square meter floor area		• CO_2 eq./cubic meter of oil eq. • CO_2 eq/unit of output • Energy/unit of output	• Total CO_2 emissions/TWh • Fossil CO_2 emissions/TWh
Canada – CIPEC **(CIPEC 2001b)**			• Energy/t product • Energy/gross output • Energy/GDP • GHG emissions/t product • GHG emissions/gross output • GHG emissions/GDP	
Netherlands – Industrial Sector Agreements **(Nuijen 1998)**	• Climate-corrected energy use/unit of surface area (square meters)	• Energy use/person-km		
Norwegian IEEN **(Institute for Energy Technology 1998)**			• Energy use/t product	

2.2. Two indicator systems developed

Based on the research conducted in Section 2.1, two indicator systems were developed and proposed for China in order to define and evaluate the low carbon level of the provinces or cities. In the first indicator system, shown in Table 2, the indicators are sector-level, end-use based, and are measurable and comparable. They can also be used for benchmarking and tracking progress (Table 2). The indicator system consists of three tiers. The first tier is aggregated indicators, measured in energy or CO_2/ GDP, and energy or CO_2 /capita. The second tier is sectoral indicators (Essential Indicators) that could be used independently for evaluation of the sectoral low carbon development. These indicators include Residential final energy/capita (weather corrected), Commercial final energy/tertiary sector employees, Industrial final energy/Industry GDP, Transportation final energy/capita, and CO_2 per unit of power produced (kWh). The third tier indicators (Major indicators) are important for identifying gaps and potentials within each sector. Often data exist but are not publicly available for this level. As such, simple surveys and data collection may be required to be undertaken by different government agencies such as local DRCs, statistic bureaus, construction commission, transportation bureaus, and forestry bureaus in order to obtain the necessary data.

Table 2 The Indicator System Proposed for Low Carbon Province /City Development

		Essential Indicators	Major indicators
Aggregated indicators		• Primary energy per unit GDP • CO_2 per unit GDP • Primary energy per capita • CO_2 per capita	
LBNL low carbon city indicator		• Indexed and weighted	
Sectoral indicators	Power Sector	• CO_2 per kWh generated	• Share of renewable in electricity supply (%) • Thermal power plant efficiency (gce/kWh)
	Industrial Sector	• Final energy per unit industrial value added	• Physical efficiency (energy per ton of product) in industrial subsectors, e.g., iron & steel, cement, aluminum, ammonia
	Commercial Sector	• Final energy per commercial floor area (recommended) • Final energy /employee	• Compliance with building efficiency codes (%) • Registered and certified LEED buildings (m^2/total m^2) • Green buildings or other certification (m^2/total m^2) • Installed capacity of integrated renewable or CHP in buildings/m^2 • Space heating intensity (MJ/m^2-HDD)
	Residential Sector	• Final energy /capita	• Compliance with building efficiency codes (%) • Registered and certified LEED buildings (m^2/total m^2) • Green buildings or other certification (m^2/total m^2) • Space heating intensity (MJ/m^2-HDD)
	Transportation Sector	• Final energy/capita	• Passenger energy or CO_2 per person-kilometer(MJ/p-km, or ton of CO_2 /p-km) • Freight final energy /ton-kilometer traveled (MJ/t-km, or ton of CO_2/t-km) • Share of alternative fueled (hybrid, CNG, EV, NG) vehicles of the total vehicle fleet (government and private, buses, cars, trucks) (%) • Public transit use (number of public transit trips per capita) • Kilometers of public transit per 100,000 population (km/capita)
	Land Use and Waste Management	• Volume of waste disposed-landfill/capita	• Area share of mixed–use zoning (residential and commercial) (%) • Area share of green space and agricultural land (%) • Composting/capita (t/capita)

First tier Second tier Third tier

The above indicator system (in Table 2) is comprised of performance indicators. It needs to be noted that many provinces/cities in China are still developing along an industrial pathway and are far from being low carbon because of the industrialization and focus on economic development and improvement of people's life. Thus, there is also need for the establishment of low carbon management indicators that can be used to evaluate the actions and efforts the cities are taking or have taken to achieve a low carbon society in conjunction with the performance-based indicators proposed above. To address this need, a second indicator system has also been developed and is presented in Table 3. In addition, local governments can identify the gaps and potentials in different sectors, and take actions for improvement. The indicators are categorized in line with the policy menu discussed in Chapter 3.

Table 3 The Indicator System for Low Carbon Management

Category	Description		Metrics
Planning and Management	Establish a mid-long term low carbon development plan		(Y/N)
	Complete a carbon emissions inventory		(Y/N)
	Establish a measuring and reporting system for carbon emissions for Key Energy-Consuming Enterprises		(Y/N)
Low-Carbon Energy Supply	Target	Establish energy-saving and carbon/CO_2 emission reduction targets for power sector	(Y/N) (If Y, provide target values)
		Establish target for share of renewables in electricity supply	(Y/N) (If Y, provide target value)
	Standard	Compare coal consumption for power supply between local average level to national advanced level	(provide value)
	Management	Implementation of efficiency dispatch	(Y/N)
		Punitive power pricing for energy intensive industries Differential pricing (inclining block rates) for residential electricity use	(Y/N) (Y/N)
	Demonstration	DSM, EPP demonstration projects (implementation of DSM regulation)	(Y/N)
Low Carbon Industry	Target	Establish energy-saving and carbon emission reduction targets for industry sector	(Y/N) (If Y, provide target values)
	Standard	Implementation of minimum energy use standards for 22 energy-intensive products in key enterprises	(Y/N)
		Adoption and implementation of energy efficiency reach standards	(Y/N)
		Add another one: Implementation of energy management standards (e.g. ISO 50001)	(Y/N)
		Enforcement of energy-efficiency standards for industrial equipment	(Y/N)(If Y, provide compliance rate)
	Incentive	Energy-saving incentives for enterprises (energy-saving per unit)	(Y/N) (If Y, provide value)
	Management	Implementation of energy audits	(audited plants/total plants)
		Energy-efficiency benchmarking/compare energy use per unit and comprehensive energy use of main products to advanced levels in the same sector	(provide values)
		Energy-use reporting systems for key energy-consuming enterprises	(Y/N)
	Demonstration	Pilots and demonstration of manufacturing energy efficiency labeling programs such as Energy Efficiency Star	(Y/N)
		Pilots to introduce the use of energy managers and energy management systems	(Y/N)
Low Carbon Buildings	Target	Establish target for implementation level of residential building codes Establish target for energy consumption per m^2 of public buildings Establish target for energy use per capita in residential buildings	(Y/N) (If Y, provide target level) (Y/N) (If Y, provide target level) (Y/N) (If Y, provide target level)

	Standard	Level of energy-saving building standards	(% of improvement)
		Enforcement of building energy codes	(Y/N) (If Y, provide compliance rate)
	Incentive	Incentives for green buildings/low energy buildings	(Y/N) (If Y, provide value)
		Incentives for ESCOs in building energy conservation	(Y/N) (If Y, provide value)
		Incentive to increase market share of energy-efficient appliances	(eg. government procurement, cooperative procurement) (Y/N) (If Y, provide value)
	Demonstration	Demonstration of green, LEED, or other certified buildings	(Y/N) (If Y, provide m2/total buildings m2)
Low Carbon Transport	Target	Establish targets for energy-savings and GHG emissions reduction for transport sector	(Y/N) (If Y, provide target values)
		Establish target for share of public transport Establish target for share of non-motor vehicle	(Y/N) (If Y, provide target level) (Y/N) (If Y, provide target level)
		Establish target for MRT (such as BRT and railway transport)	(Y/N) (If Y, provide target level)
	Standard	Adoption and implementation of reach standard for fuel economy and GHGs emissions for newly sold vehicles	(Y/N)
		Enforcement of policy controlling for small-sized vehicles in cities	(Y/N)
		Adoption of urban planning/construction standards encouraging resource conservation and low-carbon development	(Y/N)
	Incentives	Incentives for new-energy vehicles, clean and small-sized vehicles	(Y/N)
		Incentive policies for public transport and non-motor vehicles	(Y/N)
	Demonstration	Demonstration of new energy vehicles	(Y/N)
		Dedicated transport infrastructure for city pedestrian and non-motor vehicles (e.g., bike lanes)	(Y/N)(If Y, provide km/capita))
Agriculture, Forestry and Land Use	Target	Establish target for percentage of forest coverage city green space	(Y/N) (If Y, provide target value)
		Establish target for utilization of biogas Establish target for recycling rate of municipal wastes Establish target for composing rate	(Y/N)(If Y, provide target level) (Y/N%)(If Y, provide target level) (Y/N%)(If Y, provide target level)
Low Carbon Technology	Demonstration projects of key low carbon technologies		(# of projects)
	Share of investment in R&D of low carbon technologies		(%)
	Incentive policies on application of low carbon technologies		(Y/N)
Supporting Measures	Carbon tax or fossil-fuel energy consumption tax		(Y/N)
	Carbon emission permit trading		(Y/N)

3. Creating a Low-Carbon Development Plan

This section presents essential steps that are commonly used in the creation of a low-carbon development plan. The guidance here focuses on the city level; similar steps can be undertaken at every level, from enterprise, to city, province, and country. Since the 11^{th} FYP, China has set targets for improving energy intensity of the economy, including energy saving targets across economic sectors. China's announcement of a national carbon intensity goal in December 2009 focuses on energy-related carbon dioxide (CO_2) per unit of economic output (GDP). The intensity goals, along with economic goals such a 'circular economy,' necessitate preparation of a Low-Carbon Development Plan.
A Low-Carbon Development Plan combines elements of a Climate Action Plan with a city's economic planning. These elements can combine for a successful and sustainable economy:

> *"In a sustainable economy, people live and do business in ways that are good for the economy, the environment, and for communities. The usual tradeoffs between growth, sustainability and equity are not necessary. Businesses are more efficient, innovative and competitive internationally. The local talent pool is deeper. Business activity reinforces our commitment to sustainability and our leadership in sustainability contributes to a thriving local economy. All residents have access to quality jobs and share in the growth of the economy." (City of Portland 2009)*

The essential steps (also shown in Figure 2) are:

1. **Leadership Commitment**
2. **Conduct Energy and Carbon Emissions Inventory**
   a. Identify Main Sources of Energy and Carbon
   b. Identify Options for Energy and Carbon Savings (rough analysis)
3. **Set Targets**
   c. Forecast Energy, Carbon, and GDP under different Scenarios (Business-As-Usual, Savings Scenario)
   d. Set Targets Based on Scenario Forecasts
   e. If time is available, Set Targets based on detailed analysis of Potential Savings, Policies and Measures (see next step)
4. **Create a Low-Carbon Development Plan (Climate Action Plan + Low-Carbon Economic Plan), with Policies and Actions to Meet Targets**
   f. Analyze and select Policies and Actions (detailed analysis, including co-benefits, costs, and savings)
   g. Clearly state the goals for each action and how progress will be measured
5. **Implement Policies and Actions**
   h. Identify and Allocate Responsibility
   i. Set aside funding for implementation
   j. Set Timetables
   k. Support policies with incentives, penalties, training and public outreach

6. **Monitor, Report and Verify Progress**
7.

Figure 2 Essential Steps in Climate Action Planning

Source: ICLEI n.d.

The first essential step is commitment by the city's leadership. With the city's attention turned to low-carbon development, and sufficient staff and time and resources committed to the effort, the city can successfully develop and implement its low-carbon plan.

3.1. Emissions Inventory

Following commitment by city leaders, the next step in making a Low-Carbon Development Plan is the preparation of a carbon, or GHG, **Emissions Inventory**. In order to choose effective actions and policy mechanisms, it is necessary to know where the emissions are coming from; thus the need for an inventory. In addition to identifying the sources of GHG emissions, the inventory provides a baseline for identifying potential savings and for measuring progress.

Greenhouse Gases. China's announcement of a national carbon intensity goal in December 2009 focuses on energy-related carbon dioxide (CO_2). This document gives guidance on the two main carbon-based GHGs: carbon dioxide (CO_2) and methane (CH_4).[4] CO_2 emissions are primarily from energy consumption of fossil fuels, as well as from non-energy industrial processes (like cement production), and forest loss. Methane emissions arise from agriculture (especially rice production), animal husbandry, other land use, industry (e.g., coal-bed methane), and waste decomposition.

[4] Note that a comprehensive emissions inventory would include all *six* greenhouse gasses recognized under the Kyoto Protocol: CO_2, CH_4, N_2O (from fertilizers and manure), SF_6 (from electrical systems, magnesium production), HFCs (refrigeration, semiconductor manufacturing, aluminum smelting), and PFCs (aluminum and semiconductor production).

Basic Approach for Emissions Inventory. The Emissions Inventory is a best estimate of emissions from activities in the city or province – not a precise measurement. Data on activities in different sectors (such as energy consumption in industry and residential buildings) is used along with emission factors to estimate emissions, using the formula:

Activity Data x Emission Factor = Emissions

A baseline inventory—for example, emissions in 2005—combined with estimated future emissions—for example, in 2015 and 2020—enables your locality to set targets.

Scope of the Inventory. Since some emission-generating activities may cross city boundaries, it is important to clearly define the scope of the emissions inventory, to know what emissions get counted by the city. Internationally-recognized inventory protocols have defined three emission scopes: (1) direct, (2) indirect, and (3) associated emissions (WRI-WBCSD GHG Protocol; Clean Air-Cool Planet 2010; ICLEI). Table 4 explains what emissions are counted under each scope.

Table 4 GHG Emissions Inventory Scope

Emissions Scope	Scope Acitivities
Scope 1: Direct Emissions: Generated Within City Boundaries	▪ Direct Energy Consumption within the City (fuel for Industry, Heating, Cooling, Electricity generation, Infrastructure, etc.) ▪ Transportation within the City ▪ Land Use and Waste Management within the City
Scope 2: Indirect Emissions: Due to Activities Within City Boundaries, Generated Outside City Boundaries	▪ Import of Electricity and Heating used in the City
Scope 3: Associated Emissions: Due to City Activities, Occuring Across or Outside City Boundaries	▪ Intra-regional Transportation ▪ City Waste in Landfills outside the City

Source: Clean Air-Cool Planet 2010.

Scope 1 Direct Emissions come from fuel consumed in the city, for example from the heating of Residential and Commercial buildings, as well as Public (government) buildings. Fuel consumed directly by industrial enterprises within city boundaries may be the largest source of direct carbon emissions for many cities. Scope 2 Indirect Emissions are just as important; many cities and enterprises import their electricity from electric utilities outside city boundaries and must count the carbon emissions from generating the electricity the city uses. Scope 3 Associated Emissions are also important, as they account for carbon emissions from the transport of goods and people across city boundaries.

Data Needs. Basically, the Emissions Inventory covers sources of CO_2 and CH_4 from energy consumption and waste-related activities in the following sectors: Electric Power, Industrial, Residential, Commercial, Transportation, Land Management (Agriculture and other Land Use, rural and urban), and Waste. City staff preparing the carbon emissions inventory must work with the utilities supplying electricity to the city to obtain data on: kilowatt-hours (kWh) sold within the city; sector break-down of kWh sold (industrial, commercial, residential, government); and fuel mix of electricity generation.

The sectors can be further disaggregated if more detailed data can be obtained through statistics or other data collecting efforts. For example, the transportation sector could be broken down by road, rail, water and air; the commercial sector could be broken out by different types of buildings and activities, from retail to information centers; the industry sector can be disaggregated by sub-sectors or processes. For each of the aggregated or disaggregated sectors, data on the type of fuel use such as electricity, natural gas, fuel oil, steam, etc. need to be collected. Depending on the locality's structure, industrial process-related emission could also be included. The basic emission sources and data needed are summarized in Table 5.

Table 5 Data Needs for a Greenhouse Gas Emissions Inventory

Sector	Data on emission sources
Electric Power	Energy mix and amount of generation: kWh from coal, natural gas, oil, hydro, wind, solar, nuclear, etc.
Industrial	Electricity and fuel (natural gas, coal, heat, others) consumption
Residential	Electricity and fuel (natural gas, coal, heat, others) consumption Building floor space and type
Commercial	Electricity and fuel (natural gas, coal, heat, others) consumption Building floor space and type
Transportation [5]	Electricity and fuel (gasoline, diesel, others) consumption Mix of Transport Modes (feet, bicycle, motorbike, bus, light rail, train, auto, truck) Vehicle Efficiencies (Fuel Economy) for each mode Vehicle Miles Traveled (VMT) on local roads, for each mode VMT on highways (related to the jurisdiction)
Land Use	Hectares of food production, by type (rice, wheat, etc.) Numbers of cattle, pigs, horses Hectares of Forest cover (existing, removed, added)
Waste	Total landfill waste (tonnes) Typical composition of waste (organic matter, plastics and other non-degradable material, land-cover materials)

The energy and other data on emission sources and activities (Table), combined with emission factors (

Table), yields a GHG emissions inventory. In
Table , note that coal generates the highest emissions per unit of energy, whereas wind and solar have no emissions in their operation. Thus tracking energy use by fuel, as well as emissions by activity (by sector), is important for low-carbon development.

[5] Note on Transport emission in the GHG inventory: At the city level, data on fuel use by all private and public vehicles in the city are likely not available. Cities therefore often turn to surveys and estimates of per person travel habits (mode mix, fuel economy, VMT) and use that data along with population data. At the provincial level there is published data on transport fuel consumption, but city level data may be unpublished.

Table 6 CO2 Emission Factors

Energy Source	Emission Factor	Units
Coal	95	t CO_2/TJ
Oil	73	t CO_2/TJ
natural gas	56	t CO_2/TJ
electricity	*	*depends on generation energy sources
hydropower	~0	t CO_2/TJ
wind	0	t CO_2/TJ
solar	0	t CO_2/TJ

Source: IPCC 1997.

Figure 3 and Figure 4 show an example of a GHG emissions inventory, by sector, and by source for the city of Portland, Oregon. Portland was one of the first US cities to initiate a low-carbon development plan and serves as a model for other cities. Portland is also fortunate to derive a large share of its electricity from hydropower, which lowers its carbon inventory. At present, cities in China have a higher proportion of emissions from the industrial sector, and from coal, as shown in Figure 3 and Figure 4. Thus there is much opportunity in Chinese cities for energy saving, reducing the share of coal, and developing non-industrial sectors of the economy.

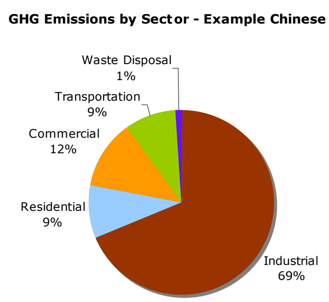

Figure 3

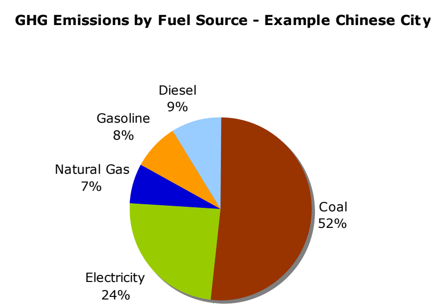

Figure 4

Figure 3 and Figure 4 GHG Emissions Inventory, by Sector and by Fuel – Example Chinese City

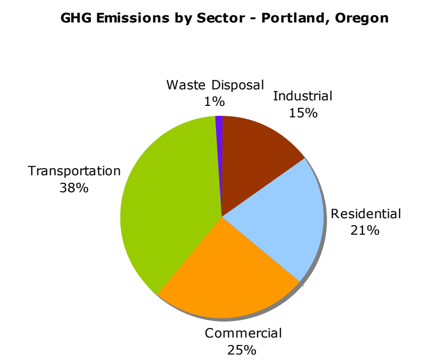

Figure 5

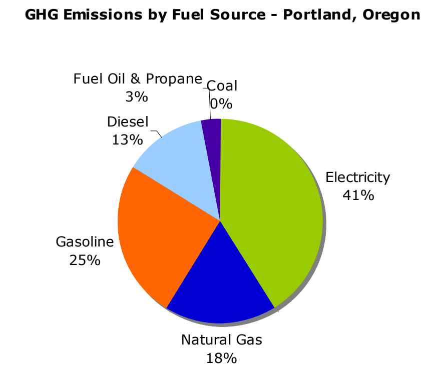

Figure 6

Figure and Figure GHG Emissions Inventory, by Sector and by Fuel – Portland, Oregon

Source: City of Portland 2009.

3.2. Target-Setting

After completion of the Emissions Inventory, provinces should set **Targets**, in the form of energy and carbon savings, or improvements in efficiency and intensity. Targets can be set through scenarios or emission reduction potential analyses, evaluating the impact of the policies.

Type of Target. Targets need to be measurable and reportable, so that progress toward goals can be tracked. A physical target is preferable—such as absolute CO_2 emissions, or energy use, or amount of wind energy—because it can be measured and has a direct influence on the health of the city and province. Economic targets are important, too; the goal is to have an economy that is low-carbon and sustains well-being.

Targets for emission reduction can be set as either intensity targets or absolute targets.[6] The goal of an intensity target is to reduce energy use or emissions per unit of product or floor area or economic output, while an absolute target aims to achieve a certain total level of energy savings or GHG emissions reductions.

An absolute target is defined in terms of a total amount of energy that will be used or GHG emissions that will be emitted in the target year. The advantages of absolute targets are that they are relatively

[6] Hybrid targets are also used. For example, Royal Dutch/Shell has a corporate-wide absolute target that is implemented through a combination of intensity targets at lower levels of the company (WBCSD/WRI 2004).

simple to set, identify an absolute quantity of energy use or GHG emissions that will be released to the atmosphere at a specific point in time, and are transparent in that additional data and calculations are not required to evaluate if the absolute target is met. Disadvantages include the fact that the economic activities at a certain location (or the products produced at a specific enterprise) can change over time, resulting in significantly different structures in the target year as compared to the base year. Such changes can be significant enough to require adjustments to the base year or to the target, especially at the enterprise level. Another disadvantage is that accomplishing an absolute target may be difficult if there is significant economic growth. Similarly, decreasing growth could lead to a situation where an absolute energy use or GHG emissions reduction target is achieved without undertaking any GHG mitigation options (WBCSD/WRI 2004).

Intensity targets can use either an economic or physical value for the denominator. For example, the GHG intensity of a cement company can be measured as energy use per value added (economic intensity target) or GHG intensity per ton of cement produced (physical intensity target). The advantages of intensity targets are that they measure energy or GHG trends independent of production growth or decline and recalculation of target or base year goals is not needed if there are changes in product mix or production volume. In addition, such targets can allow comparison of enterprise performance with other enterprises that produce similar products or with best practice. The disadvantages are that since the target is independent of production growth, the level of actual GHG emissions in the target year is not set and therefore could be higher than the base year, depending upon production trends (WBCSD/WRI 2004). Another disadvantage is that developing an intensity target for enterprises that produce a variety of products can be more complicated.

Targets that use an economic-based denominator are typically used when aggregating across a heterogeneous mix of products or activities. Analyses have shown, however, that targets that use a physical-based denominator more accurately track actual trends in emissions or energy intensity, as they are more closely linked to the emission-producing processes. Economic intensity targets are influenced by economic variability over time due to changes in market prices of the products or relative changes in prices (or value added) of different products (Freeman et al. 1996; Worrell et al. 1997). However, heterogeneity of an enterprise or of activities can make development of physical intensity targets difficult for some situations. As a result, there has been increased attention to the development of suitable physical metrics and indices (Phylipsen et al. 1998; Farla 2000; Nanduri et al. 2002).

Setting the Target Value: Scenarios of Future Energy and Carbon**:** Once the **type** of overall Target is decided—absolute energy or carbon savings, or improvement in **carbon intensity** of the economy—the next step is to set the **value** of the target, for example a **20%** improvement in carbon intensity of the economy between the year 2010 and 2015. The target value is set by making forecasts of energy and carbon under different scenarios, based on city planning, anticipated population change, and potential energy and carbon savings. Typically, at least two scenarios are examined: Business-As-Usual Scenario, and Savings (Reduction) Scenario.

One example of setting an absolute CO_2 emissions target at the city level (from a California city) is shown in Figure 7. The figure shows a Business-As-Usual Scenario (emissions rising steeply), a Baseline year (horizontal line), and emissions in Carbon Saving Scenarios (curves that eventually slope downwards). Targets—as amount of CO_2 saved, and as percent change over time—are then set based on the difference between the scenarios. The city set an Overall Target of reducing CO_2 emissions 15% between the year 2005 and 2020. They also set a longer-term goal of 35% reduction by the year 2030. The city used information from its General Plan (economic plans, infrastructure, population, transportation) to forecast the scenarios. The city also used guidance on carbon saving policies from the International Council for Local Environmental Initiatives (ICLEI), similar to this guidance manual.

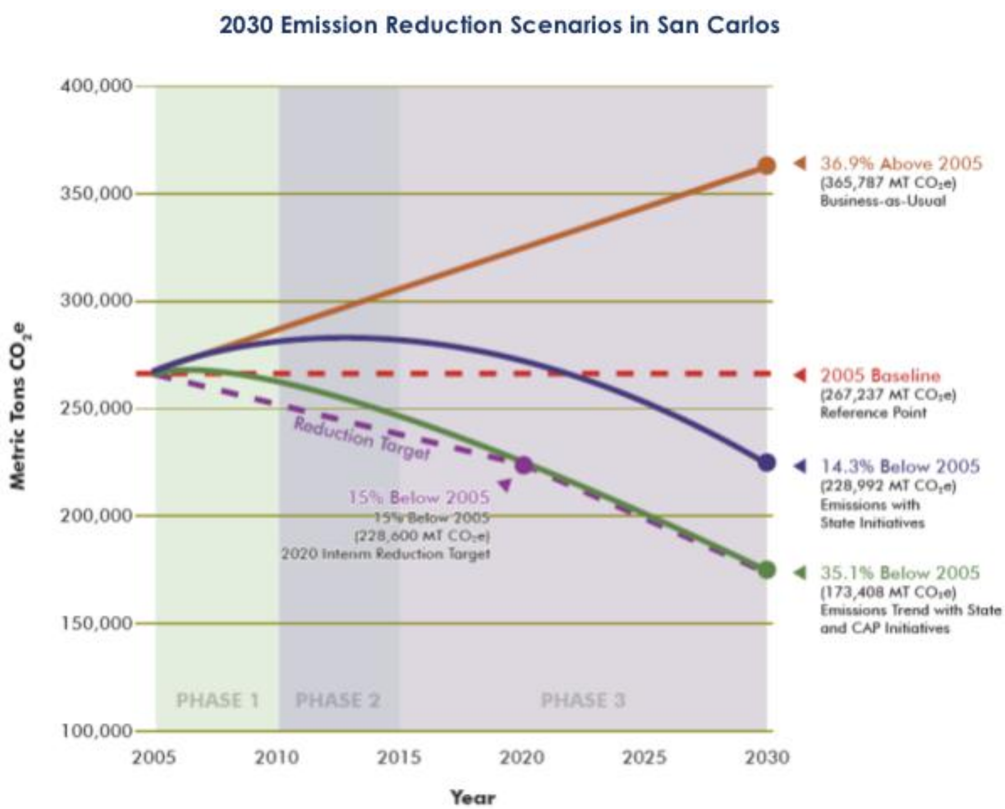

Figure 7 Carbon Targets, Baselines, and Savings Needed: Example of CO_2 Emissions Targets at the City Level

Source: City of San Carlos Climate Action Plan 2009.

3.3. Choose Policy Mechanisms for a Low Carbon Development Plan

This guidance document offers many examples of possible policies and actions cities could choose to meet their targets. Each city will choose their best fit of policies, based on the mix of emission sources in their GHG emissions inventory; the actions offering the biggest energy and carbon savings for the city;

and the costs of the actions. Because the situation is different for each city (e.g., existing efficiencies, energy pricing, renewable energy resources), the costs will vary across cities.

It is very important to choose actions that yield the biggest savings; if most of your city's current and projected emissions are from industry, you need actions that significantly reduce energy and carbon from industry. Also keep in mind which emission sources are growing fastest; for most Chinese cities, energy use and carbon emissions are rising quickly from buildings (electric appliances, heating, and cooling), from passenger transportation, and from increasing transport of products and food. So even though emissions from the building sector may seem relatively small now, actions are needed to prevent unhealthy increases.

Rough Review of Potential Actions. As the rest of this report details, a variety of policies and actions are needed. How can a city choose which policies it needs to meet its Target? As an example, a city in California first did a **rough review** of nearly 100 potential policies and actions. A city task force considered how the potential actions addressed their mix of emission sources (based on the Emissions Inventory and the Forecast Scenarios). They examined rough estimates of energy and carbon savings, and considered—in qualitative terms—the likely benefits and costs of each action. They also looked at experience with the potential policies in other cities.

One of the actions considered in the rough review was a new permit requirement that buildings should be sited considering shade from the sun, prevailing winds, landscaping, and sun screens on windows, to reduce energy use for cooling and heating. The city found that the state government was recommending this action. They also found that this action would be a natural, low-cost way of reducing energy costs to building owners. This action would also make the whole city more comfortable during hot summers, by reducing the urban 'heat island' effect from so many air conditioners, and providing more shade to people as well as buildings.

Detailed Analysis and Selection of Actions. After the rough review of potential actions, the city chose a shorter list of actions for **detailed analysis**, to show how those actions could collectively meet the overall Target. The actions were closely connected to information in the Emissions Inventory and Scenarios, addressing particular sectors and emission sources. The actions were also chosen through a process of public meetings, including ideas from businesses, residents, and students. As stepping stones to meeting the overall Target, the city grouped the actions under sector-specific Goals (or Objectives). Table shows the overall Target and sector-specific Goals. For each Goal, several Policies and Actions are chosen to meet the Goal.

Table 7 Example of Targets and Sector-specific Goals in a Low-Carbon Development Plan: Portland, Oregon

Overall City Target: Reduce CO_2 **emissions by 40% between 1990 and 2030**. Long-term Target: Reduce CO_2 emissions by 80% between 1990 and 2050.
Sector 1. Buildings and Energy Goal 1. Reduce the total energy use of all buildings built before 2010 by 25 percent. Goal 2. Achieve zero net greenhouse gas emissions in all new buildings and homes. Goal 3. Produce 10 percent of the total energy used within Multnomah County from on-site renewable sources and clean district energy systems. Goal 4. Ensure that new buildings and major remodels can adapt to the changing climate.
Sector 2. Urban Form and Mobility (Transportation) Goal 5. Create vibrant neighborhoods where 90 percent of Portland residents and 80 percent of Multnomah County residents can easily walk or bicycle to meet all basic daily, non-work needs and have safe pedestrian or bicycle access to transit. Goal 6. Reduce per capita daily vehicle-miles traveled (VMT) by 30 percent from 2008 levels. Goal 7. Improve the efficiency of freight movement within and through the Portland metropolitan area. Goal 8. Increase the average fuel efficiency of passenger vehicles to 40 miles per gallon and improve performance of the road system. Goal 9. Reduce the lifecycle green-house gas emissions of transportation fuels by 20 percent.
Sector 3. Consumption and Solid Waste Goal 10. Reduce total solid waste generated by 25 percent. Goal 11. Recover 90 percent of all waste generated. Goal 12. Reduce the greenhouse gas impacts of the waste collection system by 40 percent.
Sector 4. Urban Forestry and Natural Systems Goal 13. Expand the urban forest canopy to cover one-third of Portland, and at least 50 percent of total stream and river length in the city meet urban water temperature goals as an indicator of watershed health.
Sector 5. Food and Agriculture Goal 14. Reduce consumption of carbon-intensive foods. Goal 15. Significantly increase the consumption of local food.
Sector 6. Community Engagement (Public and Business) Goal 16. Motivate all Multnomah County residents and businesses to change their behavior in ways that reduce carbon emissions.
Sector 7. Climate Change Preparation Goal 17. Adapt successfully to a changing climate.
Sector 8. Local Government Operations Goal 18. Reduce carbon emissions from City and County operations 50 percent from 1990 levels.

Source: City of Portland 2009.

Note that the city of Portland doesn't yet have the authority to mandate carbon-reducing actions for businesses or the public. So their Climate Action Plan doesn't include specific goals for Industry. Chinese cities and provinces are given the authority to set energy and carbon saving goals for enterprises under their jurisdiction, so Climate Action Plans in China will include Industrial Goals and Actions. Indeed, industrial sector actions are crucial. For goals and actions related to electric power, Chinese cities will need to work with provincial-level government and electric utilizes to improve the fuel mix and efficiency of electric power *supply*. Cities can, however, play an active role in managing the *demand* for electric power in city buildings and enterprises.

3.4. Develop implementation plans

Effective implementation of the Low-Carbon Development Plan must include clear designation of responsibility, timetables, and assignment of budget and staff in both government and enterprises. In addition, policies and actions should include incentives and supporting measures, penalties, training, and public outreach. Implementation can also be more effective when a goal is measurable, when there is a specific metric or indicator specified, such as reducing the energy used per tonne of product, or reducing the amount of energy used per square meter of commercial floor space.

In the example above from the city of Portland, the Action Plan included implementation details. Some actions were required by the year 2012, so that carbon savings could be achieved by the target year of 2030. The actions specified who is responsible: commercial building owners must conduct energy performance benchmarking; the city should work with businesses to create an investment fund. The actions included supporting incentives, such as tax credits and low-cost financing for building retro-fits. The Goal was measurable: reduce the total energy use of all existing building by 25%.

As an example of detailed Policies and Actions a city might chose to meets its Goals and Overall Target, the City of Portland chose six near-term actions just to meet its Goal 1 of reducing the total energy use of all buildings built before 2010 by 25 percent (by the year 2030). To realize that goal, the city identified six actions (see Table 8) to be completed before the year 2012 (City of Portland 2009).

Table 8 Example of Detailed Policies and Actions to Meet Goals and Target: Portland, Oregon

Sector 1. Buildings and Energy: Goal 1. Reduce the total energy use of all buildings built before 2010 by 25 percent.
Actions to take by 2012:
(i) Establish an investment fund of at least $50 million to provide low-cost financing to residents and businesses;
(ii) Require energy performance ratings for all homes;
(iii) Require energy performance benchmarking for all commercial and multi-family buildings;
(iv) Provide other resources and incentives for carbon-reducing actions;
(v) Work with partner organizations to promote improved operation and maintenance practices in all commercial buildings.
(vi) Establish a City business tax credit for installing solar panels and eco-roofs (green roofs) together.

Source: City of Portland 2009.

For each of the actions, the city made best estimates—wherever possible—of the likely energy and carbon savings. All the actions and Goals together should achieve the city's Overall Target.

Figure 8 provides another example of an implementation plan, this one from the city of San Francisco.

Commercial Buildings

Public Goods Charge (PGC) funded commercial demand side management programs should be continued and expanded. These programs should be customized for the San Francisco building stock.

Next Steps:

- Continue implementation of SF Environment/PG&E Peak Energy Pilot (PEP) commercial programs.
- Develop agreements with local business organizations.
- Identify high-energy use buildings and businesses.
- Increase training of building operations and maintenance staff.
- Design and implement efficiency retrofit programs that include turnkey services.
- Promote peak load reduction and peak pricing tariffs.
- Obtain energy and peak load data to measure and evaluate progress.

Implementing Agencies:
PG&E, SF Environment

Funding Sources:
Utility ratepayers (through Public Goods Charges), CEC, DOE, EPA

Progress Indicators:

- Decreased demand (kilowatts) and energy use (kilowatt-hours, therms)
- Increased program participation rates

Figure 8 Example of an Implementation Plan for Energy Saving in Commercial Buildings

Source: SFDOE and SFPUC 2004.

3.5. Monitoring and Reporting Progress

Progress on low-carbon development must be tracked with **Monitoring**, including **Reporting** and **Verification (MRV)**. It is crucial to track the progress of the programs and evaluate the results to guarantee the achievement of the targets. Based on reports and monitoring, cities should periodically review their progress, to see if more effort is needed on implementation, or if more policies and actions are needed.

As part of verifying progress toward their targets, cities should separately track energy, carbon, and economic data, in relation to sectors and emission sources. Even if the target is set in terms of economic energy intensity or carbon intensity, it is important to distinctly gather the data than goes into a bundled intensity number. For example, energy intensity is expressed in terms of energy per unit of economic output [tce/ 10,000 RMB economic output]. In order to monitor and verify progress on intensity, data reporting must include data on energy, and data on economic activity, in addition to the resulting intensity number.

The Chinese government has already established energy reporting requirements for key enterprises; some enterprises must report quarterly, while others report annually. Cities can utilize this data for their GHG inventories and low-carbon development plans. Public reporting of more data, along with reporting progress toward goals, focuses attention and effort from the public and enterprises, and helps to achieve results. City government websites are an effective means for publicly tracking progress on energy, carbon, and low-carbon economic development.

Considering the timeframe of China's Five-Year Plan, cities should examine progress quarterly (for the most significant policies and actions) and annually (for progress toward the Overall Target). Cities outside of China re-examine policies and actions every one to three years. Considering the rapid pace of development in China, Chinese cities would do well to examine actions on an annual basis.

4. Policies and Actions to Achieve Low Carbon Growth

This section includes policy and actions in each sector, the description of the policies, the performance metric, GHG emission reduction potential, and the cost effectiveness where the information is available.

It is important to understand the cost-effectiveness or the relative costs associated with each policy or action. California's Global Warming Solutions Act defines cost-effective or cost-effectiveness as "the cost per unit of reduced emissions of greenhouse gases adjusted for its global warming potential."[7]

Estimation of savings potential and costs are based on underlying analyses – such as projection of "business-as usual" 2020 emissions and the magnitude of possible reductions from any given measure. Thus, comparability among analyses conducted for different locations is difficult. In China, each individual province needs to establish its inventory and baseline, as well as examine the potential areas for actions first in order to determine the cost-effectiveness of the policies and actions. Thus the data provided in this document on cost may not be applied directly but rather should serve as a reference.

Policymakers consider binding energy saving targets and other measures that will create numerous opportunities for business and society at large. Current EU policy on energy efficiency is based on the Action Plan for Energy Efficiency adopted in 2006. This six-year Action Plan, which runs from January 1, 2007 to December 31, 2012, is aimed at achieving a 20 percent reduction in energy consumption by 2020. It includes dozens of proposed measures to improve the energy performance of products, buildings and services, to improve the yield of energy production and distribution, to reduce the impact of transport on energy consumption, to facilitate financing and investments in efficiency, to encourage and consolidate rational energy consumption behavior and to step up international action on energy efficiency.

The 20 percent reduction in energy consumption by 2020 parallels other targets set by the European Commission: a 20 percent reduction in greenhouse gas emissions (compared to 1990 levels) and 20 percent of electricity sourced from renewable energy, both by 2020. (It should be noted that, while these later targets are legally binding, the energy efficiency target is not.)

The biggest energy savings expected to result from implementation of the 2006 Action Plan are in commercial and residential buildings, with savings potential estimated at 30 and 27 percent respectively. Next in terms of estimated potential savings are: transportation (26%), and manufacturing (25%). Reaching these potentials would correspond to overall savings estimated at 390 million tonnes of oil equivalent (Mtoe) each year, or €100 billion per year up to 2020. They would also help reduce CO_2 emissions by 780 million tonnes per year.

[7] HSC §38505(d)) (The AB32 Scoping Plan fact sheet has a nice summary: http://www.arb.ca.gov/cc/facts/scoping_plan_fs.pdf

4.1. Industry Actions

The industrial sector policies and actions described here consist of the following direct actions:

- target-setting
- standards

These direct actions are supported by the following policies and actions:

- financial incentives
- energy audits
- benchmarking
- information dissemination

4.1.1. Target Setting

Policy Description

Target-setting for energy efficiency or GHG emissions reduction is a common practice; a recent survey identified 23 such programs in 18 countries around the world, including countries in Europe, the U.S., Canada, Australia, New Zealand, Japan, South Korea, and Chinese Taipei (Taiwan) (Price 2005). Targets are typically either voluntary commitments or negotiated agreements, but can also be mandatory targets assigned by the government as in the case of China's Top-1000 Energy-Consuming Enterprises Program. Targets can be agreed upon by individual companies or by industrial sectors through organizations such as industrial associations.

Key elements of a comprehensive target-setting program are the target-setting process, identification of energy-saving technologies and measures, development of an energy-savings action plan, development and implementation of energy management protocols, development of financial incentives and supporting policies, monitoring progress toward targets, and program evaluation. The process for target-setting will be discussed here; other program elements will be addressed in later sections.

The process for setting energy efficiency or GHG emission reduction targets involves making a preliminary assessment of the energy efficiency or GHG mitigation potential of each industrial facility which includes an inventory of economically-viable measures that could be implemented. These assessments, which can be made by the company themselves or by an independent third party, are then provided to the government and form the basis for discussions and negotiations related to target-setting between the industries and the government.

Voluntary commitments are often made by companies either individually (and announced through websites or annual reports) or through government programs. The U.S. Environmental Protection Agency's (EPA's) Climate Leaders is comprised of approximately 200 companies that have committed to undertake a corporate-wide inventory of their greenhouse gas (GHG) emissions, set aggressive reduction targets, and report their progress annually to the EPA. The targets must be set at the corporate level (including at least all U.S. entities), set a base year of the more recent year for which data are available, be achieved in 4-6 years, and be set as an absolute GHG emission reduction target. Companies submit their proposed goal to the EPA using the Goal Proposal Template. The EPA evaluates each proposed goal by comparing it to the projected GHG emissions improvement rate for the sector, taking into consideration the company's current emissions intensity (U.S. EPA 2010a).

Voluntary commitments are also made by industrial sectors. For example, the Cement Sustainability Initiative (CSI) of the World Business Council for Sustainable Development (WBCSD), which is made up of 23 cement companies operating in more than 100 countries, requires its members to sign a charter committing to using the CSI CO_2 protocol to publicly report baseline CO_2 emissions, develop a mitigation strategy, establish targets, and report CO_2 emissions annually (CSI n.d.; WBCSD 2010). The International Aluminium Institute has 14 sustainable development voluntary objectives including a commitment for its members – which represent about 80% of global aluminium production - to reduce emissions of perfluorocarbons (PFCs) per tonne of aluminium produced by at least 50% by 2020 compared to 2006 (which is equivalent to a 93% reduction compared to 1990), to reduce smelter electrical energy use per tonne of aluminium by 10% in 2010 compared to 1990, and to reduce energy use per tonne of alumina produced for the entire industry by 10% by 2020 compared to 2006 (IAI 2009).

The World Steel Association, with 180 members that produce approximately 85% of the world's steel, has committed "take positive action to achieve further reductions in greenhouse gas emissions and to combat climate change" through the following actions (WSA 2007; WSAS 2010):

- Promoting the wider implementation of the most efficient technologies used in modern steelmaking sites.
- Undertaking research and development into new technology solutions which will radically reduce the level of CO_2 emissions into the atmosphere for each ton of steel produced.
- Maximizing both the recycling and re-use of end-of-life steel, and the value of steel industry by-products.
- Accounting for and reporting on a common basis the industry's CO_2 emissions and its progress on reaching its targets over time.

In the U.S. ClimateVISION (Voluntary Innovative Sector Initiatives: Opportunities Now) program, 11 industrial sectors have committed to sector-wide energy or GHG emissions reduction targets (see Table 9). These are voluntary targets that have been announced in support of the ClimateVISION goal to "identify and pursue cost-effective options to improve the energy or GHG intensity of industry operations by accelerating the transition to technologies, practices, and processes that are cleaner, more efficient, and capable of reducing, capturing or sequestering GHGs" (U.S. DOE n.d.; Herzog et al. 2006).

Table 9 Intensity Targets Under U.S. Climate VISION Initiative

Sector	Target Metric	Stringency/ Timeframe	Pledging Industry Group	Percent Sector Covered (U.S.)
Aluminum	GHGs (excluding energy) per ton of aluminum	53% below 1990 levels by 2010	Voluntary Aluminum Industry Partnership	98
Automobile manufacturing	GHGs per vehicle produced	10% below 2002 levels by 2012	Alliance of Automobile Manufacturers	90
Cement	CO_2 per ton cement product	10% below 1990 levels by 2020	Portland Cement Association	95
Chemicals	GHGs per unit production	18% below 1990 levels by 2012	American Chemistry Council	90
Electric power	GHGs per megawatt hour	3% to 5% below 2000–2002 levels by 2010–2012	Six different trade associations ("Power Partners")	100
Forest products	Not specified	12% below 2000 levels by 2012	American Forest & Paper Association	—
Lime	CO_2 from fuel combustion per ton product	8% below 2002 levels by 2012	National Lime Association	95
Minerals	GHGs from fuel combustion per ton product	4.2% below 2000 levels by 2012	Industrial Minerals Association, N. America	60–100[1]
Oil and gas (refining)	Energy per unit production	10% below 2002 levels by 2012	American Petroleum Institute	—
Steel	Energy per ton steel produced	10% below 1998 levels by 2012	American Iron and Steel Institute	70
Railroads	Transport-related GHGs per mile	18% below 2002 levels by 2012	Association of American Railroads	100[2]

Sources: Climate VISION (http://www.climatevision.gov/) and association websites.
Notes: [1] 80% of soda ash, 100% of borates, and 60% of merchant sodium silicates. [2] Represents Class I freight railroads. "—" means unknown.

Source: Herzog et al. 2006.

In China, the first voluntary commitments were undertaken by two iron and steel enterprises that participated in an energy-efficiency agreement pilot project in Shandong Province in 2003. The commitments had a base year of 2002 and set performance targets for 2005 (Price et al. 2003). Over this period, Jinan Iron and Steel saved 292,000 tce (8.6 PJ) and reduced energy consumption per ton of steel by 9.5% while Laiwu saved 130,000 tce (3.8 PJ) and reduced its energy intensity by 9% (Wang 2007). By 2009, Shandong government had signed agreements with about 400 enterprises that all undertook energy and/or emission reduction commitments. The government's goal is to increase this to 500 enterprises in 2010. Additional commitments have been made by enterprises in Jiangsu, Jiangxi, and Guangdong provinces; a total of 534 enterprises have made such voluntary commitments to date (Jiang 2010).

The UK Climate Change Program was established in 2000 to meet both the country's Kyoto Protocol commitment of a 12.5% reduction in GHG emissions by 2008-2012 relative to 1990 and the domestic goal of a 20% CO_2 emissions reduction relative to 1990 by 2010 (DEFRA 2006). A key element of the Climate Change Program is the Climate Change Levy, a tax on the use of energy (natural gas, coal, liquefied petroleum gas, and electricity) applied to industry, commerce, agriculture, and the public sector. Through participation in Climate Change Agreements (CCAs), energy-intensive industrial sectors negotiated energy-efficiency improvement targets. Companies that meet their agreed-upon target are given an 80% discount from the Climate Change Levy.

In the UK, the process for setting the Climate Change Agreement targets began with information-gathering on the part of the government. The government obtained information regarding energy efficiency potential in energy-intensive industries from a variety of sources (good practice guides and case studies, new practice case studies, information on future practices, a report on projections of industrial sector carbon dioxide emissions under a business-as-usual scenario, and two scenarios that included all cost-effective and all technically-possible technologies (Shock 2000; ETSU 1999). Then, individual companies in the ten largest energy-consuming sectors made estimates of what energy-efficiency improvements they could make based on an assessment of their potential and provided this information to their trade associations. The assessment included what would be expected under business-as-usual and what could be achieved if all cost-effective measures were adopted, which was based on recent history of efficiency measures, rates of technology uptake, expected growth rates, and investment plans. Once this information was gathered, negotiations took place with each sector. The sector offered a target for the whole sector to the government. The government often required the industry sector to modify their proposed target to a more challenging level, based on information on cost-effective processes and general standards of energy management in the sector (Price et al. 2005a).

For the Long-Term Agreements (LTAs) in The Netherlands, negotiated agreements between the Dutch Ministries and industrial sectors consuming more than 1 petajoule (PJ) per year were established in support of achieving an overall national energy-efficiency improvement target of a 20% reduction in energy intensity between 1989 and 2000. The targets were divided among the various industrial sectors with most industries also adopting a target of 20% reduction, but some establishing different targets based on assessments of their energy-efficiency potential. For example, the petroleum refining industry's overall target was a 10% reduction, while the target for Philips Lighting was a 25% reduction.

The process for establishing the industrial sector targets began with a preliminary assessment of the energy-efficiency potential of the sector by the industry. A quantified target was then set for the improvement of energy efficiency in the sector, based on the outcome of the study. A Long-Term Plan (LTP) described how the sector planned to realize its target. The Long Term Agreements (LTAs) include commitments for individual companies, such as the preparation of an energy conservation plan (ECP) and annual monitoring of developments in energy efficiency, expressed using an energy efficiency index (EEI). Then NOVEM,[8] the Dutch Agency for Energy and Environment, established an inventory of economically-viable measures that could be implemented by the companies in each industrial sector and based on this inventory set a target for energy efficiency improvement for each sector (Nuijen and Booij 2002). The LTA for the period 1989-2000 met its target and more with an improvement of the average energy efficiency of 22.3%.

In Japan's Keidanren Voluntary Action Plan on the Environment, which commits to stabilizing greenhouse gas emissions of Keidanren members at 1990 levels by 2010, sector-based savings targets

[8] Was renamed SenterNovem and is now NL Agency.

were set voluntarily by 38 sectors in 1997. The number of sectors has since grown to 58, including 35 from industrial and energy-converting sectors. Individual firms commit to targets within their industrial associations but these are not legally binding. Individual targets are set following technical and economic analyses of energy-saving technologies and potential. Firms have chosen absolute targets, intensity targets, and targets for improving the energy efficiency of products. Of the 35 industrial sectors, 12 committed to absolute CO_2 emissions reduction targets, 9 to CO_2 intensity reduction targets, 5 to absolute energy use reduction targets, and 15 to energy intensity targets (Wakabayashi and Sugiyama 2007).

In the Top-1000 program, targets were set by the National Development and Reform Commission (NDRC) of China for each enterprise in order to support the provincial-level targets and to reach the overall savings target of 100 Mtce for the Top-1000 program. Initially, NDRC set preliminary targets for each enterprise taking into consideration their general situation such as which industrial sector they belonged to since the potential energy savings vary by sector, as well as the general technology level of the enterprise, if known. The targets were not based on detailed assessments of energy-savings potential of each enterprise or each industrial sector. This approach was taken due to time constraints.

Performance Metric

There are three performance metrics for target-setting programs:

1. The number of enterprises with target-setting contracts
2. The number of enterprises that meet or surpassed their targets
3. The average savings per participating enterprise

GHG Emission Reduction Potential

GHG emissions reductions by U.S. EPA Climate Leaders companies are estimated to be equivalent to more than 50 $MtCO_2e$ per year (U.S. EPA 2010b). Given that there are 195 companies currently in the program, this is an average emissions reduction of approximately 256,000 tCO_2e/company/year.
In the Dutch LTA program, the average target was a 20% increase in energy efficiency over 1989 levels by 2000. The LTA program ended in 2000 with an average improvement in energy efficiency of 22.3% over the program period (Nuijen 1998; Kerssemeeckers 2002; MEA 2001). It is estimated that industries saved 150 petajoules (PJ) during the program period (Nuijen and Booij 2002), about ½ of which was stimulated by the LTAs (Blok et al. 2004). Thus, the industries in the program saved a total of nearly 11 $MtCO_2$ and of that, 5.5 $MtCO_2$ was due to the program while the remaining savings would have occurred without the program.

The UK Climate Change Agreements have resulted in even larger CO_2 emissions reductions. Table 10 shows that during the first target period (2001-2002) total realized reductions were nearly three times higher than the target for that period (Future Energy Solutions 2004). Sectors did better than expected because industry underestimated what they could achieve via energy efficiency. When negotiating the targets, most companies believed that they were already energy-efficient, but when they actually managed energy because of the CCA targets, companies saved more than they thought that they could, especially through improved energy management (Pender 2004). Industry realized total reductions that were more than double the target set by the government during the second target period and that were nearly double the target during the third and fourth target periods (AEA Energy & Environment 2009; DEFRA 2005; DEFRA 2007; Future Energy Solutions 2005).

Table 10 Results of the UK Climate Change Agreements: Periods 1-4

Absolute Savings from Baseline	Actual (Mt CO_2/year)	Target (Mt CO_2/year)	Actual minus Target (Mt CO_2/year
Target Period 1 (2001-2002)	16.4	6.0	10.4
Target Period 2 (2003-2004)	14.4	5.5	8.9
Target Period 3 (2005-2006)	16.4	9.1	7.3
Target Period 4 (2007-2008)	20.3	11.1	9.2

Source: AEA Energy & Environment 2009.

There are approximately 9000 facilities participating in this program. If the annual emissions reductions of 20.3 $MtCO_2$ achieved in 2007 and 2008 are divided evenly among these 9000 plants, the average emissions reductions are 2255 tCO_2/plant/year.

In November 2009, China's National Development and Reform Commission announced that the Top-1000 program had surpassed its target energy savings of 100 Mtce, saving 106 Mtce by the end of 2009 (NDRC 2009). Dividing this savings over 5 years by the approximately 1000 participating enterprises results in savings of 20,000 tce/plant/year. Using a conversion factor of 2.5 t CO_2/tce results in estimated average per plant savings of 5,000 t CO_2/year.

Cost-Effectiveness

Evaluations of the LTA1 program found that the agreements helped industries to focus attention on energy efficiency and identify cost-effective options that met commonly used investment criteria (Korevaar et al. 1997). The energy savings from this program are the result of a comprehensive effort to increase implementation and development of energy-efficient practices and technologies in industry by removing or reducing barriers. This highlights the importance of offering a package of measures that includes financial, technical, and informational assistance instead of a set of individual measures. A review of the LTAs noted that in addition to the energy savings – and at least as important – the agreements "placed the issue of energy conservation on corporate agendas" (MEA 2001).

A 2002 evaluation of the LTA1s found that 30% to 40% of the energy savings achieved during the program could be "considerable or entirely" stimulation by the signing of the LTAs. These savings were comprised of investments in the replacement of existing equipment (32%), investments in retrofit measures (18%), CHP investments (22%), good housekeeping (9%) and others non-categorized measures (22%) (Kerssemeeckers 2002). A more recent evaluation calculated that the cost of the LTA1s was about

$10 per tonne of CO_2 reduced, assuming the savings last for 10 years and using a social discount rate of 5% (Blok et al. 2004).
In Sweden, the Programme for improving energy efficiency in energy-intensive industry (referred to as "PFE") was introduced following the adoption of an electricity tax in 2004. At the end of PFE's second year in 2006, 117 companies representing about one fifth of Sweden's total electricity consumption are participating in the program. Nearly all of the companies have now submitted their first reports on energy efficiency improvement activities undertaken, including energy audits and analysis of their energy use as well as introduction of certified energy management systems. In 2006, 98 companies submitted their two year report and outlined nearly 900 energy efficiency improvements that they plan to undertake by 2009. The improvements will cost companies about €110 million and reduce electricity consumption by 1 TWh/year, saving companies €55 million per year. In addition, the companies will receive €17 million tax reductions through their participation in this program (SEA 2005; SEA 2006; SEA 2007).

In 2007, the UK's National Audit Office reviewed the Climate Change Levy and CCAs and found that the agreements, along with the monitoring schemes, raised awareness of the potential for energy efficiency within the participating sectors. The review found that in general the benefits of the CCAs outweighed the program administrative costs (NAO 2007). UK Steel stated that "these agreements have done more to increase awareness of energy efficiency across industry than any other government scheme" (UK Steel 2007). The Food and Drink Federation noted that "in our view the CCAs have introduced a very well balanced 'carrot and stick' approach to improving energy efficiency and delivering carbon emissions reductions. More importantly, CCAs have also reinforced business and competitive benefits through lower energy bills (Food and Drink Federation 2007).

An independent evaluation of the UK Climate Change Agreement (CCA) program found that in addition to the energy and GHG emissions reductions, the program provided "positive macroeconomic effects in economic terms, with small increases in GDP and employment, and negligible changes in general inflation" (Barker et al. 2007). The authors concluded that:

> *"Our assessment supports the argument that industries can make cost-effective energy-efficiency improvements by overcoming market failures and barriers when given incentives to do so. Such policy incentives are an important part of climate change policies, particularly in the UK and other European countries. However, national policy-makers and regulators are often reluctant to press industries to achieve significant energy-efficiency improvements because of fears that these will lead to higher costs and negative impacts on international competitiveness. As the UK CCAs demonstrate, a well-designed scheme with negotiated targets for energy-efficiency improvements may actually over-achieve the targets because of an 'awareness effect' arising from the resulting focusing of attention on the potential for cost-effective improvements. Our findings suggest that, not only would stronger targets for energy-efficiency improvements be likely to lead to significant reductions in final energy demand and CO_2 emissions, but that these would also lead to economic benefits to the national economy as a whole, partly through improvements in international competitiveness."*

Finally, a 2008 report by the Environmental Audit Committee of the UK House of Commons found that businesses that signed the CCAs believe that they are more effective than the Levy. The report notes that it is extremely difficult to evaluate the results of the CCAs due to the different baseline years represented in the many agreements. The report notes that "anecdotal evidence suggest that the process of complying with CCAs has galvanized business interest in finding energy savings and that the key to this has been the incentive of the tax discount they offer." Finally, the report states that (House of Commons, Environmental Audit Committee 2008):

> "*According to economic theory, businesses should have acted rationally by seeking to reduce their costs through increased energy efficiency. In practice, they appear to have needed an extra stimulus to change their approach to energy use. This has profound implications for climate change policy more widely. If even large corporations require additional policies to drive behavioural change, this must be all the more true for small businesses, public bodies, and private households."*

It is estimated that industry saves over $832 M/year on the energy it does not need to purchase as a result of meeting the UK CCA targets (Pender 2005). Dividing that value by the approximately 9000 participants results in average annual savings of over $90,000 per year. Another analysis estimated that the benefit net costs per ton of carbon saved in 2010 from the CCAs will be \$38/tCO_2 (DEFRA 2006).

4.1.2. Standards

Energy-efficiency standards for industry can be divided into the following categories:

- *Product standards*
- *System assessment standards*
- *Process or performance-based standards*
- *Energy management standards*

4.1.2.1. Product Standards

Policy Description

Product standards, that prescribe specific requirements for maximum energy consumption of specific products are commonly used for appliances and office equipment, but are not commonly used for industrial equipment. Exceptions include motors, industrial boilers, and transformers. Mandatory minimum energy performance standards for 3-phase induction motors are prescribed in Australia, Brazil, Chinese Taipei, Costa Rica, Israel, Mexico, New Zealand, China, South Korea, and the U.S.; voluntary standards for the same motors are prescribed in the EU, India, and Malaysia.[9] Mandatory minimum performance standards for oil-fired boilers are prescribed in Canada, Chinese Taipei, and the EU.[10] An assessment of energy-efficiency standards in The Netherlands found that industrial firms prefer energy and carbon taxes to standards, but especially prefer subsidies and voluntary agreements. Experience to date with energy-efficiency standards for industry is "not encouraging" (Blok et al. 2004).

Performance Metric

The performance metric for standards on industrial equipment is the annual energy savings and avoided CO_2 emissions achieved through energy efficiency improvements.

GHG Emission Reduction Potential

Significant savings can be realized from the full implementation of product standards. One analysis of the impact of the continuous implementation and updating of motor efficiency standards for three-phase asynchronous motors in China estimates initial savings of 45 $MtCO_2$ per year for the first 5 years (2009-2014), increasing to an average savings of 88.4 $MtCO_2$ per year between 2009 and 2030 (Zhou et al. 2010).

Cost-Effectiveness

In general, appliance and equipment standards are set at levels that are deemed to be cost-effective over the lifetime of the product.

[9] CLASP, 2011.

[10] CLASP, 2011.

4.1.2.2. System Assessment Standards

Policy Description

System assessment standards go beyond a focus on a single energy-consuming piece of equipment and instead provide a standardized methodology for assessing complete industrial systems. The American Society of Mechanical Engineers (ASME) has developed system assessment standards for pumping, compressed air, steam, and process heating systems.[11] These standards outline requirements for conducting facility-level assessments for each of these types of systems. The standards define how to collect and analyze information on system design, operation, energy use, and performance as well as establish requirements for reporting the assessment results and identifying energy-efficiency improvement opportunities (U.S. CEEM 2010).

Performance Metric

The performance metric for system assessment standards is the annual energy savings and avoided CO_2 emissions achieved through energy efficiency improvements.

GHG Emission Reduction Potential

It is difficult to quantify the GHG emission reduction potential associated with the use of system assessment standards. Even so, use of these standards assists the industrial facility in identifying projects that have production benefits that are often difficult to quantify (Lung, et al. 2005). These benefits include the following:

- Operations and Maintenance
    - Reduced maintenance costs
    - Reduced purchases of ancillary materials
    - Reduced water consumption
    - Lower cooling requirements
    - Reduced labor costs
    - Lower costs of treatment chemicals
- Production
    - Reduced product waste
    - Increased Production
    - Improved product quality
    - Increased production reliability
    - Shorter process/cycle time
- Work Environment
    - Increased worker safety
    - Reduced noise levels
    - Improved workstation air quality
- Environmental

[11] Available for purchase: http://catalog.asme.org/home.cfm?CATEGORY=CS&TaxonomyItemID=3191

    - Reduced hazardous waste
    - Reduced dust emissions
    - Reduced waste water output
    - Reduced CO, CO_2, NOx, SOx emissions
- Other
    - Achieved rebate/incentive (one-time)
    - Reduced/eliminated demand charges
    - Reduced/eliminated rental equipment costs
    - Avoided delay costs (one-time)
    -

Cost-Effectiveness

An evaluation of 81 projects that were implemented based on a plant or system-specific industrial energy efficiency strategy in industrial facilities in the U.S. identified ancillary cost savings and production benefits attributable to the use of the systems assessment in 54 (66.7%) of the 81 projects. The evaluation found aggregate annual costs savings attributable to the systems assessment to be 31% of the total savings realized project savings. These savings reduced the simple payback period from 1.43 years to slightly less than one year (Lung et al. 2005).

4.1.2.3. Process or Performance-Based Standards

Policy Description

Industrial facilities in the European Union must obtain a permit to operate that meets the requirements of the Integrated Pollution Prevention and Control (IPPC) Directive, the purpose of which is to achieve integrated prevention and control of pollution from most industrial facilities in Europe (EU 1996). Under the Directive, European Union Member States must rely on BREF documents that establish performance-based standards required for operating permits for facilities that could potentially produce a significant level of pollution. The BREF documents define best available techniques (BATs) for various industrial sectors. BATs outline the most effective means for achieving cost-effective environmental protection. There are currently BREFs for 31 industries which describe the BATs for each area covered by the directive (EC 2008).

The European Commission adopted a Directive on Eco-Design of Energy-Using Products (Directive 2005/32/EC) in 2005 that requires manufacturers of energy-consuming products to design the products so that the life cycle energy consumption and environmental impacts are minimized. The Directive provides market-entry performance criteria, but does not prescribe specific standards or energy-saving targets. The standards cover 40 products, but only the motors and pumps standards are relevant to the industrial sector (Eichhammer 2009).

China has recently issued process or performance based standards covering 22 industries (General Office of the Standardization Administration of China 2008) (Table 11). Each standard provides a level of minimum energy consumption performance for existing plants, a minimum energy consumption performance level for newly constructed plants, and an advanced minimum energy consumption performance level.

Table 11 22 industries covered by process- or performance-based standards

Cement	Zinc	Electrolyzed aluminum
Crude steel	Lead	Tin
Caustic soda	Yellow phosphorus	Coal-fired power
Copper	Synthetic ammonia	Antimony
Ferroalloy	Flat glass	Carbon
Coke	Magnesium	Wrought iron alloy
Calcium carbide	Copper and copper-alloy tube	
Ceramics	Nickel	

China has also implemented a program that requires industrial production facilities below a certain size to close due to inefficiencies associated with small scale production. The *Comprehensive Working Plan of Energy Conservation and Emission Reduction* of 2007 provides targets for closing small plants and phasing out outdated capacity in 14 high energy-consumption industries (State Council 2007). Table 12 provides the achievements of this program through 2008.

Table 12 Small Plants Closure and Phase-Out of Outdated Capacity, 2006-2008

Industry	Unit	11th FYP Targets	Realized Capacity Closures 2006-2008	Share of Target
Coal mining (production)	Mt	305	250*	82%*
Cement	Mt	250	140	56%
Iron-making	Mt	100	60.59	61%
Steel-making	Mt	55	43.47	79%
Electricity	GW	50	38.26	77%
Pulp & paper	Mt	6.5	5.47	84%
Alcohol	Mt	1.6	0.945	59%
Monosodium glutamate	Mt	0.2	0.165	83%
Electrolytic aluminum	Mt	0.65	0.105	16%
Citric acid	Mt	0.08	0.072	90%
Coking	Mt	80	n/a	
Ferroalloy	Mt	4	n/a	
Calcium carbide	Mt	2	n/a	
Glass	M weight cases	30	n/a	

** 2007 data for closed capacity. The number of closed coalmines in 2007 is only about 45% of that of 2005.*

Note: n/a = not available

Sources: NDRC 2007a; CCC 2008; Feng et al. n.d.; NDRC 2009b; NDRC 2009c

Performance Metric

One performance metric for minimum energy performance standards of industrial products is the extent to which the enterprises meet either the required or advanced energy intensity levels. Another performance metric is the energy savings realized per unit of product when the advanced levels are achieved.

GHG Emission Reduction Potential

Significant energy savings and CO_2 emissions reductions could result from full realization of the "advanced minimum energy consumption" levels outlined in China's industrial energy intensity standards. Table 13 provides information on the minimum and advanced minimum energy intensity for the 22 covered sectors. The difference between these two values represents the potential energy intensity savings if Chinese industrial facilities are required to meet the advanced minimum energy consumption standards.

For example, for cement manufacturing, the minimum energy intensity for existing plants is 109 kgce/t cement. The standards define 97 kgce/t cement as the advanced minimum energy intensity level. Thus, if a cement plant improves from the minimum to the advanced minimum energy intensity level, savings of 12 kgce/t or .03 tCO_2/t cement will be realized. For a typical cement plant producing 1,000,000 tons of cement per year, the energy savings would be 12,000 tce and CO_2 emissions reduction would be 30,000 tCO_2/year[12]

[12] Assuming a conversion factor of 2.5 tCO_2/tce.

The small plant closure program can also result in significant energy savings and CO_2 emissions reductions. Table provides information on the difference in energy use between small, inefficient industrial facilities and the larger, more efficient facilities that are assumed to replace the closed facilities. Closing an inefficient cement facility that is assumed to consume 146 kgce/t cement, and replacing it with a more modern facility that is assumed to consume 106 kgce/t cement, will lead to savings of 40 kgce/t or 75 tCO_2/t cement. Based on the capacity closures through 2008, savings of 106 Mtce final energy and 242 $MtCO_2$ emissions have been realized in China through this program (Levine et al. 2010).[13]

Cost-Effectiveness

Generally, the minimum energy performance standards of industrial products are set to be cost-effective over the life-time of the products.

[13] Assuming a conversion factor of 2.4 tCO_2/tce.

Table 13 China's Minimum Energy Consumption Performance for Existing Plants, Advanced Minimum Energy Consumption Performance for Existing Plants, and Difference Between Levels (Savings)

Sector	Product/Process/Size	Unit	Minimum Existing	Advanced Minimum	Savings
Cement	2,000-4,000 tpd	kgce/t cement	109	97	12
Steel	BF-BOF	kgce/t	502	407	95
	EAF	kgce/t	92	88	4
Copper	Crude	kgce/t	800	340	460
	Anode	kgce/t	850	390	460
	Electrolysis	kgce/t	220	130	90
	Copper smelting	kgce/t	950	550	400
Caustic soda	Liquid	kgce/t	600	490	110
Ferroalloys	Ferrosilicon	kgce/t	1980	1850	130
	Electric Furnace Ferromanganese	kgce/t	790	670	120
	Ferromanganese silicoll	kgce/t	1030	950	80
	High Carbon Ferrochrome	kgce/t	900	740	160
	Blast Furnace Ferromanganese	kgce/t	1250	1180	70
Coke		kgce/t	165	125	40
Calcium Carbide		kgce/t	1200	1050	150
Ceramics	Sanitary	kgce/t	800	550	250
	Building	kgce/t	300	220	80
Zinc smelting	Zinc pyrometallurgy	kgce/t	2200	1900	300
	Zinc hydrometallurgy w/residue treatment process	kgce/t	1850	1200	650
	Zinc hydrometallurgy w/out residue treatment process	kgce/t	1200	1000	200
Lead smelting	Lead bullion process	kgce/t	460	330	130
	Electrolytic lead refining	kgce/t	170	120	50
	Lead smelting	kgce/t	650	470	180
Yellow Phosphorus		kgce/t	3600	3000	600
Synthetic Ammonia	Coal	kgce/t	1900	1500	400
	Natural gas and coke-oven gas	kgce/t	1650	1150	500
Flat Glass		kgce/weight case	18.5	16.5	2
Magnesium Smelting		kgce/t	8300	5600	2700
Copper and Copper-Alloy Tube	Copper tube	kgce/t	375	345	30
	Simple brass tube	kgce/t	400	355	45
	Complicated brass tube	kgce/t	600	550	50
	Bronze tube	kgce/t	600	480	120
	Copper-nickel tube	kgce/t	600	510	90
Nickel Smelting	High nickel sulfur	kgce/t	1100	680	420
	Electrolysis	kgce/t	1350	1100	250

	Nickel refining	kgce/t	2050	1550	500
	Nickel smelting	kgce/t	5530	3700	1830

Sector	Product/Process/Size	Unit	Minimum Existing	Advanced Minimum	Savings
Electrolyzed aluminium	Liquid aluminium	kWh/t	14400	13500	900
	Aluminium ingots	kWh/t	14300	14000	300
	Aluminium ingots resmelting	tce/t	1.9	1.8	0.1
Aluminium alloy					
Base materials	Circular ingots	kgce/t	160	140	20
	Feedstock for furnaces	kgce/t	410	340	70
Finished products	Base materials	kgce/t	180	160	20
	Circular ingots	kgce/t	340	300	40
	Feedstock for furnaces	kgce/t	590	500	90
Tin Smelting	Presmelting treatment	kgce/t	55	35	20
	Fusion	kgce/t	1100	800	300
	Refining	kgce/t	240	140	100
	Slag smelting	kgce/t	1000	750	250
Coal-fired power plants	Supercritical	gce/kWh	320	300	20
	Subcritical (600MW)	gce/kWh	330	319	11
	Subcritical (300MW)	gce/kWh	340	317	23
	Super-high pressure	gce/kWh	375	355	20
	High pressure	gce/kWh	395		
Antimony smelting					
Antimony sulfide ore	Crude smelting	kgce/t	720	600	120
	Refining	kgce/t	460	390	70
	Antimony sulfide concentrates smelting	kgce/t	1440	1200	240
Oxysulfide antimony ore	Crude smelting	kgce/t	1150	960	190
	Refining	kgce/t	460	390	70
	Oxysulfide mixed with antimony concentrates smelting	kgce/t	1820	1520	300
Jamesonite	Crude smelting	kgce/t	1200	1020	180
	Slag smelting	kgce/t	610	520	90
	Refining	kgce/t	520	400	120
	Jamesonite smelting	kgce/t	2350	2000	350
Carbon materials					
Graphite electrode	General power graphite electrode	kgce/t	4600	3960	640
	High power graphite electrode	kgce/t	5650	4860	790
	Ultra high power graphite electrode	kgce/t	6600	5650	950
Charcoal electrode	Diameter ≤1000mm	kgce/t	1150	980	170
	Diameter >1000mm	kgce/t	2050	1670	380
Carbon block	General carbon block	kgce/t	1400	1200	200
	(Semi) graphitic carbon block	kgce/t	1650	1300	350

	Microporous carbon block	kgce/t	1850	1520	330
Baking	Product diameter ≤500mm	kgce/t	580	440	140
	500mm<product diameter≤1000mm	kgce/t	660	510	150
	Product diameter >1000mm	kgce/t	1450	1100	350
Graphite-making	General power graphite electrode	kgce/t	2700	2400	300
	High power graphite electrode	kgce/t	2970	2640	330
	Ultra high power graphite electrode	kgce/t	3100	2760	340

Source: General Office of the Standardization Administration of China 2008.

Note: values are in final energy for all sectors except coke, coal-fired power plants and carbon materials.

Table 14 Assumed Energy Intensity Values for Small, Inefficient Plants and Efficient Plants For Six Industrial Sub-Sectors

Industry	Unit	Small, Inefficient Plant Energy Intensity	Efficient Plant Energy Intensity	Potential Savings in Energy Intensity	Source
		Final Energy			
Cement	kgce/t	146	106	40	(1)
Iron-making	kgce/t	457	427	30	(2)
Steel-making	kgce/t	1175	758	417	(3)
Electricity	gce/kWh	440	315	125	(4)
Pulp & paper	kgce/t	584	323	261	(5)
Electrolytic aluminium	kgce/t	5500	4820	680	(6)
		Primary Energy			
Cement	kgce/t	175	134	41	(1)
Iron-making	kgce/t	466	433	33	(2)
Steel-making	kgce/t	1611	885	726	(3)
Electricity	gce/kWh	440	315	125	(4)
Pulp & paper	kgce/t	753	506	247	(5)
Electrolytic aluminium	kgce/t	10940	9110	1830	(6)

Sources: NDRC 2009a; NDRC 2009b (1) Zeng 2008 (2) EBCSY 2009 (3) Zhang and Wang 2007; Aden et al. 2009 (4) Feng et al. n.d. (5) LBNL 2008; Feng et al. n.d. (6) Aden et al. 2009

4.1.2.4. Energy Management Standards

Policy Description

Energy management standards are used to institutionalize continuous improvement in energy efficiency within industrial facilities. These standards are typically based on the "plan-do-check-act" approach with the goal of providing guidance to industrial facility managers related to how to structure their operations in a manner that continually identifies, adopts, and documents energy-efficiency opportunities.

Energy management standards have been adopted in China, Denmark, Ireland, Japan, South Korea, the Netherlands, Sweden, Thailand, and the United States. While most of these standards include key elements such as establishing a management-appointed energy coordinator and developing an energy management plan, they are not uniform in their adoption of elements such as external validation or certification of claimed energy savings or the intervals for re-evaluating performance targets (Price and McKane 2009). To provide more standardized guidance for energy management systems, the International Standardization Organization (ISO) initiated "ISO 50001: Energy management systems – Requirements with guidance for use" in 2008. This standard will be published at the end of 2010 (Piñero 2009) and will:

- Assist organizations in making better use of their existing energy-consuming assets
- Offer guidance on benchmarking, measuring, documenting, and reporting energy intensity improvements and their projected impact on reductions in GHG emissions

- Create transparency and facilitate communication on the management of energy resources
- Promote energy management best practices and reinforce good energy management behaviors
- Assist facilities in evaluating and prioritizing the implementation of new energy-efficient technologies
- Provide a framework for promoting energy efficiency throughout the supply chain
- Facilitate energy management improvements in the context of GHG emission reduction projects
- Allow integration with other organization management systems (environment, health and safety).

Performance Metric

The performance of energy management standards is measured through the extent that the standards are disseminated to industry and their level of adoption.

GHG Emission Reduction Potential

Participants in the Energy Agreement Programme (EAP) in Ireland are required to obtain the certificate of the new Irish Energy Management System IS393 and to implement the standard to maximize energy-efficiency gains. As of 2008, 28 companies were certified with IS393 implemented onsite (1 in 2006, 9 in 2007 and 18 in 2008). EAP member companies reported energy efficiency gains of 8% in 2007 and 6% in 2008 (SEI & LIEN 2009).

Cost-Effectiveness

Experience with implementation of energy management standards at two facilities in the US indicated cost-effective savings of 5% and 14%, respectively. It is estimated that use of energy management standards will result in approximately 10% cost-effective annual energy savings over 15 years (McKane 2010).

4.1.3. Financial Incentives [14]

Tax and fiscal policies for encouraging investment in energy-efficient industrial equipment and processes operate either through increasing the costs associated with energy use to stimulate energy efficiency or by reducing the costs associated with energy efficiency investments. Various forms of these instruments have been tried in numerous countries over the past three decades. In addition, integrated policies that combine a variety of financial incentives in a national-level energy or GHG emissions mitigation program are also found in a number of countries. Such integrated policies are often national-level energy or GHG programs that combine a number of tax and fiscal policies along with other energy efficiency mechanisms such as voluntary agreements.

Incentives for investing in energy-efficiency technologies and measures include targeted grants or subsidies, tax relief, and loans for investments in energy efficiency. Grants or subsidies are public funds given directly to the party implementing an energy efficiency project. Loans subsidized by public funding

[14] Much of this section is based on information from Galitsky et al. 2004; Price et al. 2005b; Price et al. 2008.

as well as loans that are offered at interest rates below market interest rates can be directed for investments in energy efficiency. Innovative loan mechanisms include equity participation through ESCOs, guarantee funds, revolving funds, and the use of venture capital. Tax relief for purchase of energy-efficient technologies can be granted through tax exemptions, tax reductions, and accelerated depreciation. A common approach is to provide a list of technologies for special tax treatment. Depending upon the specific program, this tax treatment could be: 1) *accelerated depreciation* where purchasers of qualifying equipment can depreciate the equipment cost more rapidly than standard equipment, 2) *tax reduction* where purchasers can deduct a percentage of the investment cost associated with the equipment from annual profits, or 3) tax exemptions where purchasers are exempt from paying customs taxes on imported energy-efficient equipment.

Table 15 provides a list of financial incentive programs adopted in the European Union since 2000. Financial incentives are often combined with other policies as part of a comprehensive energy program, which increases their efficiency (Eichhammer 2009).

Financial incentives are discussed further below in the following categories:

- *Energy or* CO_2 *taxes*
- *Grants and subsidies*
- *Energy efficiency loans and innovative financing mechanisms*
- *Tax relief*
- *Differential electricity pricing*
- *Rewards/incentives*

Table 15 Financial Incentive Programs in the EU since 2000.

Small	Large	Code	Title	Starting Year	Ending Year	Semiquanti-tative Impact
Enterprises						
	x	BEL5	Promotion of Cogeneration	2005		Low
	x	BG1	Energy Efficiency Act (EEA) – Mandatory Industrial Audits for Energy Efficiency	2006		High
x		BG2	Grants for energy audits in SME	2006		Medium
x		CZ3	Operational Programme Industry and Enterprise 2004-2006	2004	2006	Medium
x		GER36	Special fund for energy efficiency in SME´s (Sonderfonds Energieeffizienz in KMU)	2008		High
x		LV15	Investments in Clean Fuels	2009	2013	Medium
	x	CY3	Governmental grants/subsidies scheme for the promotion and encouragement of RES, energy saving and the creation of a special fund for financing or subsidising of these investments	2003		High
	x	FRA3	FIDEME: fund for investment in environment and rational use of energy	2000		Low
	x	FRA4	FOGIME: Guarantee fund for energy conservation	2000		Low
	x	HUN9	HU51 Environment and Energy Operative Programme	2007		Unknown
	x	IRL11	Combined Heat and Power (CHP) Grants Programme	2006		Medium
	x	ITA15	Efficient electric motors and inverters	2007		Medium
	x	RO3	Management of energy demand and development of the energy balance sheets	2001	2010	High
	x	RO7	Grant-supported credit line for Romania that has been established by the European Commission and the European Bank for Reconstruction and Development.	2008	2010	Medium
	x	RO8	The promotion of ESCO's	2007	2010	Medium
	x	SLO5	Financial incentives for efficient electricity use measures	2008	2016	High
x	x	BEL6	Energy audits	2002		Medium
x	x	BEL18	Financial incentives for investments in energy efficiency	2002		Low
x	x	BG3	Energy Efficiency and Renewable Energy Credit Line (BEERECL)	2004		Medium
x	x	CR1	FZOEU energy efficiency programme	2004		Medium
x	x	CR2	FZOEU and MINGORP energy audit programmes	2004		Low
x	x	CR3	FZOEU renewables promotion programme	2004		Medium
x	x	CZ2	Investment subsidies in the framework of the annual Government Programme A	2006	2006	Low
x	x	CZ6	FINESA Programme	2004		Unknown
x	x	HUN17	Third party financing within the frame of Environment and Energy Operative Programme	2007	2013	Unknown
x	x	MAL4	Support schemes for industry and SME's	2006	2013	Unknown
x	x	NOR15	Energy Consumption - Industry (Energibruk - industri)	2003		High
x	x	NOR16	Grants to local heating plants (Program for lokale energisentraler)	2008		Medium
x	x	POR2	MAPE/PRIME - Measure for Supporting the Use of Energy Potential and Rational Use of Energy	2001	2006	Medium
x	x	RO4	Financial support for investment projects to reduce energy consumption	2001	2008	High
x	x	RO5	Implementation of investment projects co-financed by Community funds	2008	2010	High
x	x	SK9	Operational Programme "Competitiveness and Economic Growth" priority line Energy	2008		Unknown
x	x	SLO2	Energy audits and feasibility studies subsidies	2003		Medium
x	x	SPA9	Energy Saving&Efficiency Strategy in Spain (E4) 2004-2012: Technologies in New Processes	2004	2012	High
x	x	UK5	The Enhanced Capital Allowance Scheme	2001		Medium
x	x	UK8	The Carbon Trust - (Various initiatives)	2001		High

Source: Eichhammer 2009.

4.1.3.1. Energy or CO2 Taxes

Policy Description

Energy or energy-related carbon dioxide (CO_2) taxes have been used in a number of countries to provide an incentive to industry to improve the energy management at their facilities through both behavioral changes and investments in energy efficient equipment. Taxes on energy or energy-related CO_2 emissions were first adopted in a number of northern European countries in the early 1990s. Such taxes are now found in Austria, the Czech Republic, Denmark, Estonia, Finland, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, and the UK. In target-setting programs that involve the use of energy taxes, such as the Climate Change Agreements in the UK and the Danish energy efficiency agreements, rewards for meeting agreed-upon targets are provided in the form of a reduction of the required energy tax (DEFRA 2004; Togeby et al. 1999). The Intergovernmental Panel on Climate Change (IPCC) found that “emission taxes do well in both cost effectiveness and environmental effectiveness” (Metz et al. 2008).

In 1990, the Danish government set a goal of reducing CO_2 emissions by 20% in 2005 compared to 1988 levels. In addition, under the Kyoto Protocol and the following EU burden-sharing agreement, Denmark is also obligated to reduce GHG emissions by 21% compared to 1990 emission levels by 2008-2012. In support of the national CO_2 reduction target, a CO_2 tax was introduced in Denmark on May 15, 1992 for households and January 1, 1993 for industry. The purpose of the tax was to address environmental protection issues as well to cover fiscal gaps and support a growing national economy by redirecting the tax revenues to the economy. All fossil-fuel burning households were required to pay €13.4 per ton CO_2 ($18.8 USD/ton CO_2).[15] However, value-added tax (VAT)-registered businesses were only required to pay €6.7 per ton CO_2 ($9.4 USD/ton CO_2) (Svenden 1997), to address concerns over international competitiveness and domestic employment. In 1996, the Danish government established the Green Tax Package, which included an additional CO_2 tax, a new SO_2 tax and new energy taxes on space heating.

While the standard CO_2 tax rate was kept unchanged, the tax base of the regular energy taxes was extended to cover what was defined as the business use of “space heating”, the CO_2 tax reimbursement scheme was rearranged and tightened (Price et al. 2005). Heavy processes are defined as energy-intensive processes. Light processes include energy consumption that is neither heavy processes nor space heating. The Danish CO_2 tax system has five levels, as displayed in Table 16.

Table 16 1996-2002 Danish CO_2 Tax for Industry (in Euro per ton of CO_2)

Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Space heating, no agreement	13.4	13.4	13.4	13.4	13.4	13.4	13.4
Space heating, with agreement	13.4	13.4	13.4	13.4	13.4	13.4	10.5
Light process, no agreement	6.7	8.0	9.4	10.7	12.1	12.1	12.1
Light process, with agreement	6.7	6.7	6.7	7.8	9.1	9.1	9.1
Heavy process, no agreement	0.7	1.3	2.0	2.7	3.4	3.4	3.4
Heavy process with agreement	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Source: DEA 2005; Ericsson 2006.

[15] 1 Euro = 1.4 USD.

The energy tax was imposed on energy consumption used for ordinary space heating including hot water. During 1996-1998, the energy tax was about €5.5 per GJ ($8.1 USD/GJ). After 1998, the level of energy tax was increased to about €6.8 per GJ ($10 USD/GJ) (DEA 2005; DEA 2000). SO_2 tax was gradually introduced since 1996. Currently, it is €1.34 ($1.88 USD) per kilo of emitted SO_2, or €2.68 ($3.75 USD) per kilo of sulfur in the fuel. The total Danish Green Tax for different energy sources and energy use in 2000 is shown in Table 17. Similar to previous taxation, revenues from the Green Tax Package were used to lower tax on labor and income, subsidize energy-efficient measures, and provide special subsidize for small companies (DEA 2005).

Table 17 Energy, SO2, and CO2 Taxes for Different Energy Sources and Uses

Energy Source	Unit	Heavy Process, No Agreement	Light Process, No Agreement	Space Heating	Sulfur Content
Electricity	Euro/MWh	5	14	87	
Natural gas	Euro/1000 m^3	7	27	244	0
Gas oil	Euro/m^3	10	34	269	0.1
Fuel oil	Euro/t	21	49	315	0.5
Coal	Euro/t	22	43	221	0.6

Source: DEA 2005.

In 1991, the Swedish Carbon Tax was introduced. Industries were only required to pay 50% of the tax to maintain competitiveness and certain high energy-using industries such as commercial horticulture, mining, manufacturing, and the pulp and paper industry were fully exempted from the tax. In 2004, an EU directive led to an increased electricity tax of €0.5/MWh which affected most Swedish industrial companies.

The UK Climate Change Program was established in 2000 to meet both the country's Kyoto Protocol commitment of a 12.5% reduction in GHG emissions by 2008-2012 relative to 1990 and the domestic goal of a 20% CO_2 emissions reduction relative to 1990 by 2010 (DEFRA 2006). A key element of the Climate Change Program is the Climate Change Levy, a tax on the use of energy (natural gas, coal, liquefied petroleum gas, and electricity) applied to industry, commerce, agriculture, and the public sector. The revenues from the levy are returned to the taxed sectors through a reduction in the rate of employer's National Insurance Contributions and used to fund programs that provide financial incentives for adoption of energy efficiency and renewable energy (DEFRA 2004).

Performance Metric

The performance metric is the reduction in energy use or CO_2 emissions associated with implementation of the tax.

GHG Emission Reduction Potential

A comparison of energy or CO_2 taxes in European countries concluded that "substantial reductions in carbon emissions are generally achieved, and, with them, reductions in emissions of NOx, SOx and other air pollutants." Carbon savings as a percentage of baseline emissions ranged from savings of 25% to an increase of 10% in 53 reviewed analyses. Eighty percent of the reviewed analyses indicated emissions savings. Emissions increases were the result of taxes that stimulated substantial economic growth where the growth more than offset the savings from investments in energy efficiency. The design of the energy or CO_2 tax program is extremely important; most programs recycle revenues back into the economy through lowering of other taxes such as social security, personal income, or value added taxes (Hoener and Bosquet 2001).

A recent evaluation of the UK Climate Change Levy estimates that it will reduce CO_2 emissions by 13.6 $MtCO_2$ in 2010 over a business-as-usual case (DEFRA 2006).

Cost-Effectiveness

A comparison of energy or CO_2 taxes in European countries found that "policy packages that include the use of a portion of the environmental tax revenues to finance energy efficiency or renewable energy improvements are more likely to result in positive employment and GDP impacts" (Hoener and Bosquet 2001).

It is estimated that the cost-effectiveness (defined as benefit net of costs per ton carbon saved) of the UK Climate Change Levy is \$42.35/tCO_2 saved (Cambridge Econometrics 2005; DEFRA 2006).

4.1.3.2. Grants and Subsidies

Policy Description

Beginning in the 1970s, grants or subsidies for investments in energy efficiency were among the first policy measures to be implemented and remain the most widespread fiscal incentives used today. A recent survey found that 28 countries provide some sort of grant or subsidy for industrial energy efficiency projects (WEC 2004). Grants or subsidies are public funds given directly to the party implementing an energy efficiency project. Those providing the grants or subsidies, generally the public sector, do not seek a direct financial benefit in the form of return on investment. Due to problems with free-riders, prohibitively high transaction costs or complex and long procedures to process forms, international best practice is to restrict such grants or subsidies to certain types of investment, such as a selected list of equipment with a long payback time but high efficiency gains, or to investments of a certain size or level of cost-effectiveness.

Developing countries with higher risk market environments for investments may find that direct public funding in the form of grants or subsidies is a viable option for encouraging investment in energy efficiency. Public funds may also be needed where competition with more traditional investments such as infrastructure expansion receives most of the available financing, where non-asset based energy efficiency projects are perceived to be riskier than asset-based investments, where energy efficiency projects are too small to gain enough attention or where energy prices do not reflect real costs of energy and are too low for energy efficiency projects to procure enough financial benefit for individual companies.

Australia's Greenhouse Gas Abatement Programme (GGAP) targets all sectors of the economy but focuses on large scale emission reduction projects, especially those that exceed 250,000 tonnes of CO_2 equivalent emission reductions annually.[16] In the first two application rounds, 15 projects and almost $145 million were offered, with a goal of 27 million tonnes of GHG abatement (Kemp and Macfarlane 2003). In its subsidy program, Denmark prioritized the distribution of grants and subsidies to energy-intensive industries and companies involved in a voluntary agreement (DEA 2000).

Other subsidy schemes focus more on small- or medium-sized enterprises, which may not otherwise be able to afford to undertake large energy efficiency projects. The Netherland's BSET Program focused on small- or medium-sized enterprises, covering up to 25% of the costs for specific technologies such as heat recovery, heat pumps and absorption cooling (Kræmer et al. 1997). The Scottish Clean Energy Demonstration Scheme (SCEDS) also focuses on small- to medium-sized businesses. SCEDS funds grants up to 80,000 GBP ($150,000 2005 U.S.) for development, demonstration, application and replication of energy efficiency measures and renewable technologies in Scotland.[17]

Some programs tie grants to a cost-effectiveness criterion. Thailand's Energy Conservation Program Fund (ECF), which was created in 1995 as a part of the Energy Conservation Promotion Program (ENCON)

[16] http://www.greenhouse.gov.au/ggap/index.html
[17] http://www.energy-efficiency.org/index.jsp

and is funded from a tax on petrol. ECF provides subsidies in both the public and private sectors, covering up to 50% of the costs for a facility up to 500,000 Baht (U.S. $12,000). In order for a facility to meet Thailand's cost-effectiveness criteria, Thailand's program requires that each efficiency measure achieve an internal rate of return above 9% (Brulez and Rauch 1999).

Norway's IEEN program provides grants up to 20% in any sector investing in energy management or energy monitoring. Like Thailand, Norway also tied grants to cost effectiveness in its program that ran from 1990-1993, but Norway set a maximum limit on the rate of return as well as a minimum, from 7 to 30% (MURE II n.d.). From the 487 projects given a grant, a total of 1050 GWh/year was saved with a total investment of 1,200 million NOK ($188 million 2005 U.S.). Only 16.5% of these costs were IEEN subsidized (198 million NOK or $31 million 2005 U.S.).

Austria's 2009 Combined Heat and Power Law will provide 55 million Euro for subsidies for CHP, 30% of which are allocated to industrial cogeneration plants. Subsidies for new plants range from 100 Euro/kW for plants up to 100MW to 40 Euro/kW for plants above 400MW (IEA 2010).

Since 2004, Wallonia Belgium has provided subsidies for investments in energy efficiency equipment that meets specified minimum standards, including variable speed motors for cooling, air compressors, ventilation, pumping (subsidy of Euro 100/kWh up to Euro 5000 per project for projects with a minimum energy savings of 10%); heat recovers (subsidy of Euro 50/kW or up to Euro 7500 per project); burners (subsidy of Euro 3.75 to 12.75 per KW, up to a maximum of Euro 7500 per project), condensing gas boilers (up to Euro 12,500 depending upon installation capacity); and micro-generation and high efficiency cogeneration (subsidy of 20% of cost up to Euro 15,000) (IEA 2010).

In Turkey, new legislation adopted in 2008 provides support for industrial energy efficiency projects covering 20% of project costs up to TRY 500,000. Seventeen projects were selected during the first year of this program. Financial support for these projects totaled 1 million TRY and total project investment costs were 5.1 million TRY. The projects are estimated to save 6.3 million TRY in energy costs and save 6,600 toe (276 TJ). In addition, subsidies of up to 70% of the costs of energy-efficiency training, study, and consulting services used by SMEs are subsidized in Turkey (IEA 2010).

Performance Metric

Energy saved and/or CO_2 emissions reduced per unit of funding provided.

GHG Emission Reduction Potential

Subsidies for industry can lead to energy savings and related GHG emissions reduction and have been shown to increase the market for energy-efficiency technologies (De Beer et al. 2000b; WEC 2001). A recent study in The Netherlands found that subsidies stimulated additional activities related to energy-investments and R&D that were beyond what they would have been without the subsidies (Blok et al. 2004).

Cost-Effectiveness

The experience in the EU indicates that subsidies typically address investment barriers and are usually focused on cross-cutting technologies and combined heat and power (CHP) rather than process-specific technologies since these are easier to define in a standardized manner (Eichhammer 2009). While there can be significant issues with free-riders (which can comprise ½ to 2/3 of the subsidy recipients), a Dutch study found that government costs for subsidy schemes were \$20-50/t CO_2 avoided and that the costs for implementing the subsidy scheme were only 1-7% of the subsidies provided (Blok et al. 2004). The cost-effectiveness can be improved if the subsidy schemes are more targeted in terms of who can receive the subsidies and which technologies qualify, especially excluding technologies that are already cost-effective (Blok et al. 2004; de Beer et al. 2000).

4.1.3.3. Energy Efficiency Loans and Innovative Funding Mechanisms

Policy Description

Public (or soft) loans are loans subsidized by public funding that are offered at interest rates below market interest rates for investments in energy efficiency. The goal of subsidized loans is to promote energy efficiency measures until they achieve market acceptance level and can be funded on their own. According to the World Energy Council, public loans are less popular than subsidies in the countries surveyed (WEC 2004).

Innovative funding mechanisms aimed at increasing the involvement of banks and private capital in energy efficiency investments are also being used in some countries. In an effort to reduce public debt, trends show a movement toward these types of private sector, rather than the public sector, funds. By involving the private sector who seeks profits from their loans, these countries hope to develop a self-sustaining market in the long term, while obtaining a good return on investment in the short term. Higher risk market environments that exist in developing countries and emerging economies may make it more difficult to raise financing from banks that tend to be conservative in investments, and who are not used to the idea of energy efficiency generating cash. Developing countries may also face competition with more traditional investments like expansion of industrial plants or power generation. In addition, energy efficiency projects without large capital investments are often perceived as riskier and/or are too small to attract multilateral financial institution lending.

Innovative funding mechanisms include equity participation through energy service companies (ESCOs), guarantee funds, revolving funds, and venture capital. ESCOs are private companies that provide project identification, engineering, design, installation, ongoing servicing and maintenance, monitoring and verification of savings, and/or financing of energy and energy efficiency projects. As a part of a private fund geared towards energy efficiency, the ESCO's role is to help to acquire and manage projects within the fund. According to the World Energy Council, economies in transition can especially benefit from ESCOs if initial funding can be raised or provided, although this experience is fairly recent.

With a few exceptions, such as industrial purchased steam or co-generation, ESCOs have had little impact on the development of energy efficiency projects that involve industrial systems. There are many reasons for this, including: high cost of opportunity identification and deal completion, limited replicability site to site, and lack of expertise in specific industries. ESCOs typically enter industrial markets with experience from the commercial sector and tend to concentrate on measures such as lighting and heating, ventilating, and air conditioning that are found in commercial buildings, which miss most of the energy savings at industrial sites. In recent years, suppliers of industrial system equipment have begun providing “value added” services that may include everything from a broader range of product offerings (sophisticated controls, drives, valves, treatment equipment, filters, drains, etc) to complete management of the industrial system as an outsourced provider. Their success appears to be attributable to their specialized level of systems skill and familiarity with their industrial customers’ plant operations and needs (Elliott 2002).

Guarantee funds provide a guarantee to the banks granting loans in the medium and long term. Many countries have guarantee funds, but these national funds are generally not adequate to support financing for energy efficiency projects and most of them have ceilings on the guarantees. In these cases, guarantee funds specifically for energy efficiency can be offered in addition to the national funds in order to cover credit risks associated with financing energy efficiency. To maximize their effectiveness, a good assessment of the potential benefits is key. France, Hungary and Brazil have all established guarantee funds for energy efficiency (Ademe n.d.; WEC 2004) [18]

With revolving funds, the reimbursement of the loans is recycled back into the fund to support new projects. These funds generally require public or national intervention to support them, either through subsidizing interest rates (low or zero) or by subsidizing the principal investment. They can be implemented at the local or national levels and can be applied to any sector. Thailand’s Energy Conservation (ENCON) Promotion Act helped set up the ENCON Fund. The agreement to start the fund with six financial institutions was signed in 2003 with a total of 2 billion Baht ($50 million May 2005 U.S. equivalent). The fund is fixed for three years with the intention that at that point the scheme should become self-sustaining without the need for public intervention. This trend has already begun, with more banks applying to become a part of the scheme (Energy Futures Australia Pty Ltd. and Danish Management Group (DMG) Thailand Co Ltd. 2005; WEC 2004).

The UK’s Carbon Trust is a government-funded independent non-profit organization that assists businesses and the public sector to reduce carbon emissions by 60% by 2050 as outlined in the UK Government’s Energy White Paper (UK Department of Trade and Industry 2003). The Carbon Trust provides interest-free loans to small- and medium-sized enterprises ranging from GBP 5,000 to GBP 200,000 (and up to GBP 400,000 in Northern Ireland). In addition, the Carbon Trust funds a local authority energy financing scheme, promotes the government’s Enhanced Capital Allowance Scheme, and has a venture capital team that invests between £250,000 and £1.5 million ($284,000 to $2.8 million 2005 U.S. equivalent) per deal as a minority stakeholder alongside private sector investors. VC

18 Information on Hungary’s program available through the International Finance Corporation at http://www.ifc.org/ifcext/eca.nsf/Content/SelectedProjectHungary?OpenDocument&UNID=F8F90E12332C17E9852569CF006E4CBA.

investments include early-stage carbon reduction technologies as well as management teams that can deliver low carbon technologies (Carbon Trust 2005a).

GHG Emission Reduction Potential

The UK Carbon Trust has provided 800 loans totaling 30 million GPB to small and medium enterprises, reducing CO_2 emissions by 88,000 tCO_2 per year (Carbon Trust 2010; IEA 2010).

4.1.3.4. Tax Relief

Policy Description

Tax relief for purchase of energy-efficient technologies can be granted through tax exemptions, tax reductions, and accelerated depreciation. Such schemes are found in 22 countries (WEC 2004). A common approach is to provide a list of technologies for special tax treatment. Depending upon the specific program, this tax treatment could be: 1) accelerated depreciation where purchasers of qualifying equipment can depreciate the equipment cost more rapidly than standard equipment, 2) tax reduction where purchasers can deduct a percentage of the investment cost associated with the equipment from annual profits, or 3) tax exemptions where purchasers are exempt from paying customs taxes on imported energy-efficient equipment.

Accelerated Depreciation. Accelerated depreciation programs are found in Canada, Ireland, Japan, The Netherlands, and Singapore. In Canada, the Accelerated Capital Cost Allowance Class 43.1 allows taxpayers an accelerated write-off at a rate of 30% for specified energy efficiency and renewable energy equipment instead of the standard annual rates of between 4% and 20% (Canada Department of Finance 2004). In addition, the program includes the costs of pre-feasibility and feasibility studies, negotiation costs, site approval costs, etc. (Government of Canada 1998).

In 2008, a new tax incentive was introduced in Ireland through the *Accelerated Capital Allowances* (ACA) scheme, which was designed to encourage industrial companies to procure the most energy-efficient equipment. Companies can deduct the full costs of purchased eligible energy-efficient equipment from their profits in the year of purchase. A wide range of products (about 5,000) are now under the scheme (SEI & LIEN 2009; DCENR 2009a). In phase 1 of the ACA scheme, five categories of products were included: lighting, lighting controls, motors, variable speed drives, and building energy management systems (S.I. 2008). In 2009, 24 additional technologies/products were added to the list, which include electric and part-electric vehicles and associated charging equipment, alternative energy vehicle conversion, IT infrastructure hardware and associated cooling equipment, electricity-generation equipment (plant self-use, such as solar PV, wind turbines, CHP and anaerobic digestion equipment), boiler equipment and control and recovery systems, HVAC systems, and advanced liquid-and gas-handling equipment (S.I. 2009). The detailed list of technologies can be found at the website of Sustainable Energy Ireland (SEI 2009). The Irish government estimated that the expanded ACA scheme covers “technologies responsible for 60% of the industrial energy use in Ireland” (DCENR 2009b). This scheme enables enterprises to “write off the entire cost of energy-efficient equipment in the year of purchase,” and thus to encourage more investments in energy-saving technologies and products.

In Japan, under the 1993 Energy Conservation and Recycling Assistance Law, an accelerated depreciation allowance equal to 30% of the acquisition cost is available for investments in heat pumps, floor heaters, CHP systems, district heating and cooling systems, high efficiency electric trains, low emission vehicles, energy-efficient textile manufacturing equipment, solar power systems, small- and medium-size hydro generators, and equipment for producing recycled paper and plastics (Anderson 2002).

The Netherlands also provides the Accelerated Depreciation on Environmental Investment program (VAMIL), which allows an investor to more rapidly depreciate its investment in environmentally-friendly machinery, reducing operating profits and tax payments. This program has been in effect since 1991 and includes equipment that reduces water use, soil and air pollution, noise emissions, waste production and energy use. To qualify, the equipment must have relatively good environmental impacts, be not yet widely accepted in the country, have no negative side effects, and have the potential for a substantial market in the country. The list of qualifying equipment is updated regularly. Costs associated with obtaining advice on the purchased machinery are also subject to accelerated depreciation (IISD 1994; SenterNovem 2005a).

Under Singapore’s Income Tax Act, companies that invest in qualifying energy-efficient equipment can write-off the capital expenditure in one year instead of three. Unlike the Canadian and Dutch programs, however, expenses related to acquiring information or consultant fees for identifying and analyzing the equipment purchase are not included in this program. Replacement equipment, such as new air-conditioning systems, boilers, and water pumps, along with energy-saving equipment such as high efficiency motors, variable speed drive motors, or computerized energy management systems qualify (NEEC 2005).

Tax Rebates. Programs in which companies deduct the cost of energy-efficient equipment from their annual profits are found in Japan, South Korea, The Netherlands, and the UK. Japan’s Energy Conservation and Recycling Assistance Law also provides a corporate tax rebate of 7% of the purchase price of energy-efficient equipment for small and medium-sized firms (WEC 2001). In South Korea, a 5% income tax credit is available for energy-efficiency investments such as replacement of old industrial kilns, boilers, and furnaces; installation of energy-saving facilities, co-generation facilities, heat supply facilities, or energy-saving equipment; alternative fuel using-facilities; and other facilities that reduce energy by 10% (UNESCAP 2000).

Tax Deductions. In The Netherlands, under the Energy Investment Deduction (Energie Investeringsaftrek, EIA) program, originally 40% and now 55% of the annual investment costs of energy-saving equipment can be deducted from the fiscal profit during the calendar year in which the equipment was procured, up to a maximum of €107 million. Qualifying equipment is provided on an “Energy List” and the costs associated with obtaining advice for purchased equipment can also be included. Approval is granted by SenterNovem, an agency under the Dutch Ministry of Economic Affairs. The budget for this program in 2005 is €137M (Aalbers et al. 2004; SenterNovem 2005b).

The UK's Enhanced Capital Allowance Scheme allows a business to claim 100% first-year tax relief on their spending on qualifying energy-saving technologies specified in the "Energy Technology List" on their income or corporation tax return. Businesses can write off the entire capital cost of their investments in energy-saving technologies against their taxable profits for the year during which they make the investment (HM Revenue & Customs n.d). The technologies that currently appear on the 2004 Energy Technology List are: air-to-air energy recovery, automatic monitoring and targeting, boilers, combined heat and power (CHP), compact heat exchangers, compressed air equipment, heat pumps for space heating, HVAC zone controls, lighting, motors, pipework insulation, refrigeration equipment, solar thermal systems, thermal screens, variable speed drives, and warm air and radiant heaters (Carbon Trust 2005b).

China's new law on corporate income tax, which took effect in January 2008, grants preferential tax treatment for investment in energy-saving and environmentally-friendly projects and equipment (NDRC 2008). Qualified investments receive a tax exemption for 3 years and a 60% reduction in corporate taxes in the 4th–6th year, starting from the year in which the project first generates operating income (KPMG 2008). Additionally, 10% of the investment can be credited against income tax obligations.

Tax Exemptions. A full exemption from Germany's petroleum tax is provided for highly efficient combined heat and power (CHP or cogeneration) facilities that have monthly or annual utilization rates of 70% or greater (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2004). A Romanian program exempts imported energy-efficient technologies from customs taxes and exempts the share of company income directed for energy efficiency investments from income tax (Alliance to Save Energy et al. n.d.). In November 2000, the Energy Efficiency Law was passed by the Parliament of Romania. The law covers the efficient use of energy in all areas. One element of the law is that "devices, machine tools, equipment and technologies for increasing energy efficiency are exempt of custom taxes" (CEEBICNet Market Research 2004).

Companies that join Sweden's PFE program and comply with its requirements to carry out an energy audit and analysis of their facilities, introduce and apply an energy management system, establish and apply routines for purchasing and planning, and carry out energy-efficiency measures are exempted from the electricity tax of €0.5/MWh. Based on improvements planned for implementation by 2009 in 98 Swedish companies, tax exemptions of about €17 million will be realized by these companies through their participation in this program (Swedish Energy Agency 2007).

4.1.3.5. Differential Electricity Pricing

Policy Description

In June 2004, NDRC established a policy permitting differential electricity pricing for high energy-consuming industries, including electrolytic aluminum, ferroalloy, calcium carbide, caustic soda, cement, and steel, in which electricity prices can be set based on the energy intensity level of each enterprise. Under this policy, enterprises are grouped into one of four categories based on their level of energy-efficiency: encouraged, permitted, restricted, and eliminated. The electricity price varies between different categories and was designed to phase-out inefficient enterprises and encourage efficient ones (Moskovitz et al. 2007). Enterprises in the ‘‘encouraged’’ and ‘‘permitted’’ categories pay the normal price for electricity in their areas. Enterprises in the ‘‘restricted’’ and ‘‘eliminated’’ categories pay surcharges of 0.05RMB[19] and 0.20 RMB per kWh (2006 US$0.0060/kWh and 2006 US$0.0242/kWh), respectively. As of 2006, 30 provinces had implemented this policy, covering approximately 2,500 enterprises. Between 2004 and 2006, approximately 900 firms in the eliminated category and 380 firms in the restricted category had closed, invested in energy efficiency, or changed production processes (Moskovitz et al. 2007).

In 2007, the policy was adjusted to allow local provincial authorities to retain revenue collected through the differential electricity pricing system, providing stronger incentives for provincial authorities to apply the policy (Moskovitz 2008). The differentiated electricity pricing policy, however, has not yet been fully implemented. In some areas, preferential (reduced) electricity prices were provided to some high-energy-consuming industries without authorization. This contributed to the very rapid and unplanned development of these industries. In September 2006, the State Council gave NDRC the authority to prohibit or halt preferential electricity pricing and expanded the coverage of the industries subject to differential pricing to include phosphorus and zinc smelting industry. Importantly, it further increased the electricity price for ‘‘eliminated’’ enterprises to 50% higher than the price for high-energy-consuming industries to be phased over three years and immediately increased the price differential for ‘‘eliminated” enterprises by a factor of four to 0.20 RMB per kWh (2006 US$0.0252/kWh) and for ‘‘restricted’’ enterprises by a factor of 2.5–0.05 RMB (2006 US$0.0063/kWh) per kWh (NDRC 2006).

A recent case study of the use of differential electricity pricing in the cement industry in Fujian Province found that after two years of implementation of this policy, 19.6 Mt of outdated cement production capacity was closed, reducing coal use by 1.8 Mt and reducing CO_2 emissions by 4.26 Mt (Fuzhou Electricity Regulatory Office of SERC 2009).

Performance *Metric*

Number of eliminated enterprises or amount of eliminated production capacity.

GHG Emission Reduction Potential

Based on the Fujian case study, CO_2 emissions of 220,000 tCO_2 are reduced per ton of outdated production capacity that is closed.

4.1.3.6. Incentives and Rewards

Policy Description

During the 11th Five Year Plan, China’s Ministry of Finance (MOF) and National Development and Reform Commission (NDRC) initiated a program award enterprises at a rate of 200 RMB¥ ($29) for every tce

[19] Based on a currency conversion of 2006 US$1 =7.9897 RMB (average rate of July 2006).

saved per year for enterprises in East China to 250 RMB¥ ($36) for every tce saved per year for enterprises in Mid or West China (Lu 2007; Jiang 2007, MOF and NDRC 2007) related to the implementation of five of the Ten Key Projects. The rewards and rebates are paid to enterprises that have energy metering and measuring systems that can document proven savings of at least 10,000 tce (0.29 PJ) from "energy saving technical transformation" projects. Assuming an average emissions factor for China of 2.42 tons carbon dioxide (CO_2) per ton coal equivalent, this funding is equivalent to $12 to $15 per ton of CO_2 emissions reduced (Price et al. 2008). In 2007, MOF allocated 7 billion RMB ($US 1 billion) in funding for these rewards (People's Daily 2007). During that year, 546 projects were approved, accounting for 2.8 billion RMB of the incentives (Central Government Website 2008). In 2009, MOF provided 4.322 billion RMB ($US 635 million) to support technical renovation projects at 1116 enterprises (Li 2010; Xie 2010).

In 2010, enterprises in Shanxi Province received rewards for 8 technical renovation projects with total estimated energy savings of 199,300 tce (Shanxi Provincial DRC 2010). Rewards were given for 47 technical renovation projects in Hubei Province with total estimated savings of 849,600 tce (Hubei Provincial DRC 2010).

Performance Metric
Energy saved and/or CO_2 emissions reduced per project.

GHG Emission Reduction Potential
In 2007, there was an average of 23,000 tce saved per project (at an average cost of 225 RMB/tce). In 2010, savings of 18,000 to 25,000 tce per project were experienced in two provinces.

4.1.4. Energy Audits

Policy Description
Auditing enterprises involves collecting data on all of the major energy-consuming processes and equipment in a plant as well as documenting specific technologies used in the production process and identifying opportunities for energy efficiency improvement throughout the plant, typically presented in a written report. Tools, informational materials, and other energy efficiency products are often furnished during the audit. Some audit programs, like the U.S. Department of Energy's Energy Savings Assessments program, provide a directory or network of accredited auditors.[20]

Performance Metric
The performance for energy audits can be measured by the number of energy audits conducted, identified energy saving/emission reduction potentials per audit, and realized energy saving/avoided emissions per audit.

GHG Emission Reduction Potential

[20] http://www1.eere.energy.gov/industry/bestpractices/qualified_specialists.html

In the mid-1990s, the International Energy Agency convened an expert group on industrial energy audits and a project on Energy Audit Management Procedures within the European Union's Specific Actions for Vigorous Energy Efficiency (SAVE) Programme was launched in March 1998 to evaluate energy auditing practices in the European Union. The effort interviewed energy audit experts, developed country reports, identified state-of-the-art procedures and success stories, and harmonized definitions of energy auditing. The project's final report, *The Guidebook for Energy Audits, Programme Schemes and Administrative Procedures*, explains that the core elements of an energy audit are evaluating the present energy consumption, identifying energy saving possibilities, and reporting (MOTIVA, IFE and CRES 2000).

The SAVE project report explains that there are many types of energy audits that vary in scope and complexity. Scan-type audits identify the major energy-consuming areas of a facility and point out energy-saving measures that can be applied. An example of a scan-type audit is a walk-through audit for facilities with simple energy-consuming systems, typically small and medium sized industrial facilities. Another scan-type audit is a preliminary energy audit which is typically performed by a team of energy experts and provides a breakdown of the facility's current energy consumption and identifies probably energy-saving measures. More in-depth analyzing audits include system-specific audits that identify the energy saving potential of one specific system, device, or process; selective audits in which the auditor focuses on specific systems seeking those with the major energy-saving opportunities; targeted audits in which certain low energy-consuming areas are excluded from the audit; and comprehensive energy audits that cover all of the facility's energy consumption, including mechanical and electrical systems, process supply systems, and all energy using processes (MOTIVA, IFE and CRES, 2000).

The SAVE project produced a number of additional information sources, including a *Guidebook for Energy Audit Program Developers* that provides information on training, authorization, quality control, monitoring, evaluation, energy audit models, and auditor tools based on auditing programs in 16 European countries (Väisänen 2003), a *Topic Report on Auditors' Tools* that discusses a variety of auditing tools used within European auditing programs (Ademe, 2002), and a *Topic Report: Training, Authorisation, and Quality Control that discusses* energy auditor training, authorization of energy auditors, and quality control of energy audits (Väisänen and Reinikainen 2002).

Individual plant audits conducted as part of the Dutch Long-Term Agreements included a description of the sector, an assessment of the plant's energy consumption in the base year, a survey of opportunities for energy-efficiency improvement, and a description of the monitoring and energy management techniques used (Nuijen 2002). Identified energy-efficiency measures were grouped in five categories: good housekeeping/energy management, retrofit or strategic investments, energy-efficiency investments, cogeneration, and other measures (e.g. changes in feedstock). The individual enterprise audits were done by the company itself and/or by independent consultants. The results of the audits were reported to an independent government agency, and provided the basis for final discussions and negotiations between the industries and the government to establish the final target for the sector. The assessments were further used as a basis for the company Energy Savings Plan which included an assessment of energy consumption in the base year, a survey of opportunities for energy-efficiency improvement, monitoring and energy management, research and development of new energy-efficient technologies, and demonstration projects of energy-saving measures.

As part of the Danish CO_2 Tax Rebate Scheme for Energy-Intensive Industries, energy audits of individual plants were conducted by independent, approved consultants. The energy audit was required to include the following: an energy balance for the plant with a detailed breakdown of energy consumption by processes, description of the energy-efficiency projects at the plant, including potential future projects, recommendations for energy management, and recommendations for energy conservation investments (Ezban et al. 1994). The purpose of the energy audit was to identify all profitable energy measures. In heavy processes (like greenhouse heating and production of food, sugar, paper, cement and glass) profitable refers to energy efficiency with a payback period of less than four years. In light processes (energy tax of the company exceeds 4% of the company's value added) profitable is defined by a payback period less than six years. The energy audits were carried out by either by consultants or company staff. The audits were verified by an independent certified verification agency. Sector-wide reports were also prepared. These reports provide a sector-wide analysis of energy consumption and production processes and identify the general potential for energy-efficiency improvement in the companies within the sector (Togeby et al. 1998).[21]

The Swedish National Energy Administration (STEM), as a part of the EKO Energi Agreements, provides a comprehensive inventory and analysis of energy use in a company's production and premises, and includes a list of possible actions to be taken. STEM also provides a comprehensive material flow analysis as well as an introductory comparison of the company's environmental awareness and management and guidelines based on EMAS or ISO 14001 standards (Uggla and Avasoo 2001).

Cost-Effectiveness

Energy audits can be a cost-effective way to identify energy-saving opportunities. In the U.S., energy audits undertaken at small and medium industrial facilities identified energy-efficiency opportunities that could save an average of $230,000 USD if implemented. For larger plants, energy audits provided through the Save Energy Now Program identified average potential energy savings of $1.4 million USD per audit.[22]

The U.S. Department of Energy (DOE)'s Industrial Assessment Centers, located at 26 universities throughout the U.S., perform in-depth assessments of medium-sized industrial facilities including a detailed evaluation of potential savings from energy efficiency improvements, waste minimization and pollution prevention, and productivity improvements. The assessment team surveys the plant and takes

[21] The obligation to do an energy audit before signing a voluntary agreement was removed in the revised scheme (2002). Instead of the energy audit, the participating companies must now do an energy flow screening covering the most energy-intensive parts of their production process. The purpose of the energy flow screening is not to identify profitable energy savings projects, but to identify areas or parts of the production process that are relevant to study further in special investigation (Ericsson, K., 2006 *Evaluation of the Danish Voluntary Agreements on Energy Efficiency in Trade and Industry*, http://www.aid-ee.org/documents/011Danishvoluntaryagreements.PDF).

[22] From EERE Fact Sheet, based on results of energy audits through April 2010.

engineering measurements that are the basis for the detailed analysis with related cost, performance, and payback time estimates. These results are then presented to the plant in a confidential report with findings and recommendations.[23] In 2001, the IACs performed 590 facility assessments that identified 3,350 energy efficiency recommendations with an average simple payback time of 0.9 years. Of those, facilities implemented 1,550 (46%) of the recommendations and the implemented recommendations had an average simple payback time of 0.5 years (Muller 2001).

In 2006, the U.S. DOE's Industrial Technologies Program initiated the Save Energy Now program that provides trained energy experts to perform Energy Savings Assessments at the most energy-intensive manufacturing facilities in the U.S. The purpose of the assessments is to identify immediate opportunities to save energy and money, primarily by focusing energy intensive systems such as process heating, steam, compressed air, fans, and pumps.[24] In 2006, the Save Energy Now program completed 200 assessments at large manufacturing plants and found that the typical large plant can reduce its energy bill on average by over $2.5 million per plant, for a total of $500 million in identified energy cost savings and over 4 million metric tons of CO_2 emissions reductions. The assessments targeted the largest energy-consuming manufacturing plants, consuming 1 trillion Btu or more annually, and six industries (over 80% of the assessments were in these industries): chemical manufacturing, paper manufacturing, primary metals, food, non-metallic mineral products, and fabricated metal products. Six-month follow up surveys indicated that about 7% of the recommendations have been implemented, saving an estimated $30 million annually and more than 70% of the recommendations have been implemented, are in progress, or are planned for implementation (Wright et al. 2007). Assessment reports, which include near-term, medium-term, and long-term opportunities for energy saving, are provided to the company and also posted on DOE's Energy Savings Now website.[25]

4.1.5. Benchmarking

Policy Description

Benchmarking is a method for evaluating performance indicators to determine a company's ranking compared to other companies or to a set target, goal, or threshold. There are many types of performance indicators, such as financial, productivity, safety-related, and environmental, that can be used to evaluate a company's activities. Benchmarking was first used in the 1980s by companies such as Xerox and Kaiser Associates, an international strategy consulting firm (ICMR 2002; Kaiser Associates 1988). Kaiser Associates defined a seven-step benchmarking process, as follows:

1. Determine which functions and/or processes to benchmark
2. Identify key performance indicators and performance drivers
3. Qualify and select benchmark companies
4. Measure performance of benchmark companies
5. Measure own performance

[23] http://www.iac.rutgers.edu/database/about.php
[24] http://www1.eere.energy.gov/industry/saveenergynow/assessments.html
[25] http://www.eere.energy.gov/industry/saveenergynow/partners/results.cfm

6. Specify strategies and actions to “meet and surpass”
7. Implement and monitor results

While there are many types of benchmarking, two that are especially relevant for the analysis of energy-efficiency activities are performance benchmarking and best practice benchmarking. A 2008 survey of over 450 organizations in over 40 countries found that nearly 50% used performance benchmarking and nearly 40% used best practice benchmarking (GBN 2008).
The Global Benchmarking Network provides the following definitions for performance and best practice benchmarking:

> ***Performance Benchmarking*** describes the comparison of performance data obtained from studying similar processes or activities. Comparisons of performance may be undertaken between companies – or internally within an organisation. It is useful for identifying strengths and opportunities for improvement.
>
> ***Best Practice Benchmarking*** describes the comparison of performance data obtained from studying similar processes or activities and identifying, adapting, and implementing the practices that produced the best performance results. Best practice benchmarking is the most powerful type of benchmarking. It is used for “learning from the experience of others” and achieving breakthrough improvements in performance.

Energy-efficiency benchmarking programs and tools have been developed for use in a number of industrial energy-efficiency programs around the world. Examples can be found for various types of energy-efficiency benchmarking, including peer-to-peer, self- performance over time, self-performance to national or regional average and best practice, and self-performance to international best practice. There are advantages and disadvantages to each of these types of benchmarks.

In the 1990s, Norway’s Industrial Energy Efficiency Network (IEEN) developed an extensive benchmarking program. The IEEN provided technical and financial support for companies to undertake energy management activities and assess their energy–efficiency potential through benchmarking. The IEEN developed a web-based benchmarking system that allowed members to extract information about their own energy performance in relation to other plants within the same industrial sector. Every year industry network members provided data via the internet. Participating industries included: aluminium, bakeries, breweries, fishing, meat, dairy, grain-drying, fish meal, foundry, pulp and paper, timber and sawmill, and laundries and dry cleaners (Institute for Energy Technology 1998).

The European Commission’s project on *Energy Benchmarking at the Company Level Within Industry Voluntary Agreements* developed an automated computer system to allow companies to make a comparison with "the best of a branch" regarding energy efficiency.[26] The project focused on three industrial sectors: bakeries, breweries, and dairies (EVA 2001a, b, c). Individual plants in each sector

[26] http://www.energyagency.at/projekte/ideen2.htm#aea-publ

were benchmarked in terms of production, revenue, specific energy consumption (energy use per physical unit of production), and a number of other indicators.

In The Netherlands, benchmarks were a key element of the Benchmarking Covenants in which participating large energy-intensive industrial companies agree to become one of the world's most efficient regions (regions defined as geographic areas with a production capacity similar to the Netherlands) or to be among the top 10% of the most energy-efficient plants in the world.[27] Industrial companies must consume at least 0.5 petajoules of energy per year to join the agreement. Industries pledged to be among the world's leaders in energy efficiency by 2012 at the latest. The government ensures that the participating industries are not subject to additional government policies regulating CO_2 emissions reductions or energy conservation and that new energy taxes will not be levied on the participating industries. The participating industries establish an energy efficiency plan describing how they will meet their target.

The benchmarks are established as follows:

1) Most Efficient Region. In order to be compared to similar plants in one of the world's most efficient regions, regions outside of the Netherlands that are comparable with the Netherlands in terms of size and number of processing plants and which meet the best international standards are identified. The average energy efficiency of similar processing plants in these regions is then determined. The benchmark is the average energy efficiency in the region with the highest average.

2) Top 10%. In order to be considered among the top 10% of the most energy-efficient plants in the world, the energy efficiency of comparable processing plants outside the Netherlands must be determined. These are ranked according to energy efficiency levels. The benchmark is the energy intensity of the best 10% of these processing plants.

If it is not possible to conduct either of the two studies outlined above, then the energy efficiency of the best processing plant outside of the Netherlands will be determined and the benchmark will be set at 10% below the energy efficiency of this facility. Companies can provide information supporting the use of a different percentage given their specific situation. The Benchmarking Commission will determine whether sufficient support has been provided for the claim, after receiving recommendations from the independent authority. When defining the benchmarks, account will also be taken of the anticipated efficiency improvements up to 2012. Moreover, the world leader must be redefined every four years. It will not be possible to do this in every case. For example, if a unique process is involved or if the foreign plants do not want to take part in the benchmark, then a best practice approach will be used to define the world leader. Six power generating companies and 97 industrial companies comprising a total of 232 facilities have signed the Benchmarking Covenant. These facilities have an aggregate energy consumption of 1,060 petajoules (PJ) and represent 94% of the industrial sector energy consumption and 100% of the electric sector energy consumption in the country (Commissie Benchmarking 2002).

[27] http://www.benchmarking-energie.nl/

The U.S. ENERGY STAR for Industry program is a voluntary U.S. government program that helps manufacturers protect the environment through superior energy efficiency. The program has nearly 600 corporate members in a wide range of industries. These members can take advantage of energy management resources, networking opportunities, and sector-specific energy-efficiency guidebooks that include both process-specific and utility energy efficiency measures. In addition to these resources, the ENERGY STAR for Industry program has developed a benchmarking tool for measuring how efficiently a manufacturing plant uses energy compared to others in its industry in the U.S. This industry-specific Energy Performance Indicator (EPI) tool ranks a plant based on its energy use and accounts for differences between the plants within an industry by normalizing for activities or factors that influence energy use. Plant and corporate energy managers input key operating conditions for a plant and receive a percentile score of their energy performance or efficiency. Inputs include energy use by energy type and annual production at the site.

When possible, as is permitted by the data, the EPI will relate energy to plant output as measured by units of product. The score, on a scale of 1 to 100, represents the plant's position relative to all others of similar operation within the industry in the U.S. The EPI helps companies assess the current efficiency of their plants, prioritize where they will allocate resources for improvement, and track progress. EPI benchmarking tools are currently available for automobile manufacturing plants, cement plants, container glass manufacturing plants, flat glass manufacturing plants, frozen fried potato processing plants, juice processing plants, petroleum refineries, pharmaceutical manufacturing plants, and wet corn milling plants.[28] To date, 71 industrial facilities have used the EPI tool to qualify for the Energy Star label.[29] Figure shows where these facilities are located in the U.S.

[28] http://www.energystar.gov/industry

[29] http://www.energystar.gov/index.cfm?c=industry.bus_industry_plants

Figure 9 Industrial Facilities with Energy Star Label.

Natural Resource Canada's Office of Energy Efficiency (OEE) provides guidelines for both *energy performance benchmarking* in which a company compares its physical energy intensity to the average for its sector and *best practices benchmarking* in which a company compares itself to “best in class”.[30] OEE has developed an energy calculator to assist companies in determining their facility’s energy use by fuel type.[31] Once the energy intensity is calculated, the facility can be compared to the benchmarks for energy efficiency of facilities in the cement, fish and lobster processing, fluid milk, mining (open-pit and underground bulk), petroleum refining, potash, and pulp/paper sectors that OEE has published.[32]

***Performance** Metric*

The performance metric for industrial energy-efficiency benchmarking is the number of plants that conducted either performance benchmarking or best practice benchmarking. The improvement in energy efficiency at plants as an outcome of benchmarking can also be a performance metric.

GHG Emission Reduction Potential

GHG emission reduction potential can be identified through self-performance benchmarking, or through peer-to-peer comparisons. Sectors or processes that have the greatest saving potentials can be tackled with cost-effective energy-efficient measures and technologies. The following five case studies provide further details on GHG emission reduction potential of benchmarking programs.

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[30] http://oee.nrcan.gc.ca/industrial/technical-info/benchmarking/how-to-benchmark.cfm?attr=24

[31] http://oee.nrcan.gc.ca/industrial/technical-info/tools/energy-use-calculator.cfm?attr=24

[32] http://oee.nrcan.gc.ca/industrial/technical-info/benchmarking/benchmarking_guides.cfm?attr=24

The electricity-saving potential of dairy industry participants in Norway's Industrial Energy Efficiency Network is shown in Figure which provides the benchmarking results for the dairy industry, comparing electricity use (kilowatt hour, kWh) per liter of milk produced for a number of companies (identified by 5-digit code numbers) for 1996, 1997, and 1998. Using this type of benchmarking, companies can compare their current year electricity use to their previous year electricity use and also compare themselves to other milk producers.

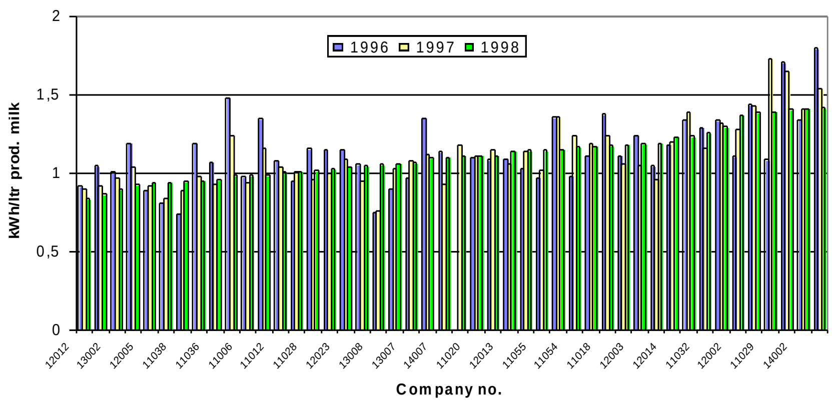

Figure 10 Comparison of Electricity Use per Liter of Milk Produced for IEEN Companies, 1996-1998.

The electricity-saving potential for participants in the European Commission's project on *Energy Benchmarking at the Company Level Within Industry Voluntary Agreements* is shown in Figure which compares the electricity use per hectoliter of beer produced to the specific energy consumption of the other beer-producing companies that participated in the program, indicating that this company's electricity intensity was slightly below the 50th percentile.

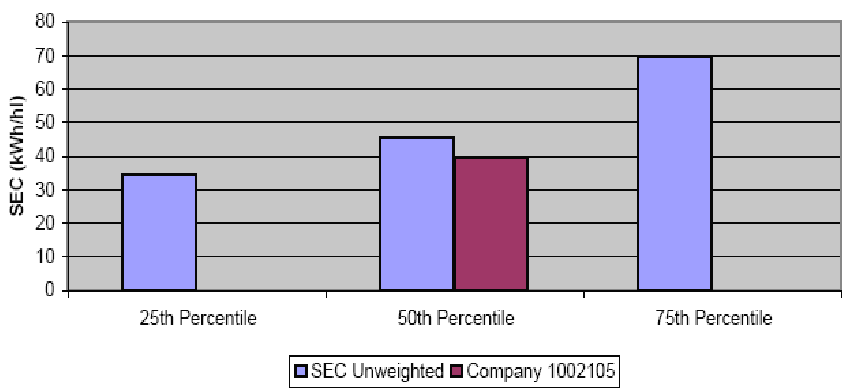

Figure 11 Benchmarking Electricity Use for Beer Production of a Company

Total expected savings from the Dutch Benchmarking Covenants program are 95 PJ in 2012, avoiding approximately 5.8 million tons of carbon dioxide ($MtCO_2$) (Commissie Benchmarking 2004).

To qualify for the EPA's Energy Star label, industrial facilities must perform in the top 25% of all U.S. plants. The difference between the actual energy use and the energy use if the facility performed at the U.S. average (50%) level for the first 17 facilities to qualify for the EPA Energy Star label is equivalent to 1.4 million metric tons of CO_2 emissions per year (Boyd et al. 2008).

4.1.6. Information Dissemination

Policy Description

Countries with strong industrial energy efficiency programs provide information on energy efficiency opportunities through a variety of technical information sources including energy efficiency databases, software tools, and industry- or technology-specific energy efficiency reports (Galitsky et al. 2004). The U.S. Department of Energy's (USDOE's) Industrial Technologies Program provides many software tools, such as MotorMaster, for assessing energy efficiency of motors, pumps, compressed air systems, process heating and steam systems.[33] Fact sheets or brochures contain information on energy efficiency methods, technologies, processes, systems and programs, or provide results from demonstration projects or annual reports. The USDOE also provides case studies that describe energy-efficiency demonstration projects in operating industrial facilities in the aluminum, chemicals, forest products, glass, metal casting, mining, petroleum, steel, cement, textiles, and other sectors[34] and sourcebooks, tip sheets, technical fact sheets and handbooks, and market assessments for steam, process heating, compressed air, and motors, pumps, and fans.[35]

Case studies providing information on commercial energy-saving technologies for a number of industrial sectors are also provided by the Centre for Analysis and Dissemination of Demonstrated Energy Technologies (CADDET).[36]

Reports or guidebooks help promote energy efficiency, advise companies on new technologies, methods or management, and give overall sectoral information. Examples include Australia's Energy Efficiency Best Practice Guides (Industry Tourism Resources 2000a, 2000b, 2003), the Netherlands' descriptions of energy efficiency projects undertaken by LTA members,[37] Norway's Industrial Energy Efficiency Network sector reports (NVE 1998), and the UK Carbon Trust technology guides.[38] The Canadian Industry Program for Energy Conservation's sector-wide energy efficiency guides provide information on energy efficiency measures for aluminum, automotive, brewery, cement, dairy, foundry, lime, pulp/paper, rubber, and solid wood industries.[39] The U.S. ENERGY STAR for Industry Energy Guides [40] include both process-

[33] http://www1.eere.energy.gov/industry/bestpractices/software.html
[34] http://www1.eere.energy.gov/industry/bestpractices/case_studies.html
[35] http://www1.eere.energy.gov/industry/bestpractices/technical.html
[36] http://www.caddet.org/index.php
[37] http://www.senternovem.nl/LTA/projects/energy_efficiency/index.asp
[38] http://www.carbontrust.co.uk/energy/takingaction/publications.htm
[39] http://oee.nrcan.gc.ca/industrial/technical-info/benchmarking/benchmarking_guides.cfm?attr=24#c
[40] http://www.energystar.gov/industry

specific and utility energy efficiency measures for breweries, cement, corn refining, fruit and vegetable processing, glass, motor vehicle assembly, petroleum refining, and pharmaceuticals (Galitsky et al. 2003a; Worrell and Galitsky 2004; Galitsky et al. 2003b; Masanet et al. 2007; Worrell et al. 2007; Galitsky and Worrell 2003; Worrell and Galitsky 2005; Galitsky et al. 2005). The U.S. DOE has also published a sector-specific study for the cement industry (Choate 2003). Some of these documents have been translated into Mandarin.[41]

As part of the Dutch Long-term Agreements 2 (LTA2), SenterNovem and representatives of the sector develop and maintain a "measurement list" of possible efficiency improvements that consists of a detailed description of the measure, investment costs, energy savings, returns on investment and if financial support is available for the measure.[42]

4.2. Building Actions

4.2.1. Target Setting

Policy Description

There are three types of target-based policies for the building sector: energy and/or carbon emission targets for new buildings, for retrofitting existing buildings, and broader voluntary and negotiated agreements.

Targets for new buildings include the United Kingdom (UK)'s target for zero energy and zero CO_2emission homes by 2016 and California's target for zero net energy for 100% new residential construction by 2020 and for commercial construction by 2030. China has also set a building target of 65% reduction in the energy intensity of new building construction. Possible co-benefits of new building targets include employment creation and improved comfort and productivity in well-designed, energy efficient buildings.

One example of retrofit targets for existing buildings is California's target of reaching zero net energy for 50% of existing commercial buildings by 2030, with the actual change in total energy use of commercial buildings as a performance metric (CPUC 2008). Chicago has set a target of auditing and retrofitting 15 million of square feet of public building with efficient HVAC equipment and lighting (ICLEI 2009). China has also set targets for total retrofit areas and provided incentives for retrofitting. Co-benefits of setting retrofit targets include employment creation and new business opportunities with greater demand for retrofitting. There may also be improved social welfare and poverty alleviation with new or expanded residential retrofit programs that specifically help low-income households reduce their energy expenditures, such as in California's plan.

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[41] http://china.lbl.gov/energy.efficiency.guidebooks

[42] SenterNovem presents lists with energy efficiency improvements for more than 20 sectors on their website: http://www.senternovem.nl/mja/tools/maatregellijsten/index.asp. To determine the return on investment (ROI), SenterNovem developed a tool to determine ROIs of measures. This Excel tool can be downloaded from: http://www.senternovem.nl/mmfiles/tvt_ncw_tcm24-111964.xls (in Dutch).

Broader voluntary and negotiated agreements on building targets are exemplified by the UK's Climate Change Agreement targets for the building sector. In the U.S., a Mayors' Climate Protection Agreement (MCPA) have been set up in 2005, and today nearly 300 mayors representing over 49 million Americans in 44 states and Washington, D.C. have signed the MCPA. The agreement urges the federal and state governments to meet or beat the target of reducing global warming pollution levels to 7 percent below 1990 levels by 2012, including efforts to: reduce the United States' dependence on fossil fuels and accelerate the development of clean, economical energy resources and fuel-efficient technologies such as conservation, methane recovery for energy generation, waste to energy, wind and solar energy, fuel cells, efficient motor vehicles, and biofuels (ICLEI 2009).

Performance Metric

The performance metric for targets of new buildings are based on the inspection and evaluation of the level of compliance at both the design and construction phases. The performance metric for retrofit targets is the total m^2 retrofitted. The performance metric for voluntary and negotiated agreements on building targets are the extent to which the target is met.

GHG Emission Reduction Potential

Targets have medium GHG emission reduction potential, with the UK Climate Change Agreement targets having achieved 15.8 Mt CO_2 emissions reduction (IPCC 2007). In Chicago's retrofit program, energy savings are estimated to result in $6 million savings annually. The annual savings upon completion have been estimated at 30,000 tons of CO_2, and 84 tons of nitrous oxides, and 128 tons of sulfur dioxide, with an overall average reduction of 0.2 ton CO_2/m^2.

Cost Effectiveness

These agreements generally have medium cost-effectiveness with the cost of emission reduction ranging from 54.5 to 104 US$ per ton CO_2 under the UK Climate Change Agreements (IPCC 2007).

4.2.2. Mandatory Standards and Codes

Besides targets, another regulatory control mechanism is mandatory standards or codes that must be followed and include both building standards and codes and appliance energy performance standards.

4.2.2.1. Building standards and codes

Policy Description

Building standards or codes which may be performance-based codes that require compliance with an annual energy consumption level or prescriptive codes that set performance levels for specific building components. Examples of existing building codes include EU directives and policies and California's Title 24.

National: In the EU, Directive 2002/91/EC [43], the Energy Performance of Buildings Directive (EPBD), sets minimum standards for the energy performance of new buildings and existing buildings that are subject to major renovation. The Directive requires all EU countries to enhance their building regulations and to introduce energy certification schemes for buildings. All countries are also required to have inspections of boilers and air-conditioners. In November of 2008, the European Commission proposed a new, more ambitious EPBD, designed, according to the Commission, “to clarify and simplify certain provisions, extend the scope of the Directive, strengthen some of its provisions so that their impact is more effective, and to provide for the leading role of the public sector.” [44] In China, the energy conservation design standard requires 50% reduction in energy intensity compared to 1980s level (County of Ventura 2010).

Leading/ Reach standard: California’s 2005 Title 24 is 20% more stringent than other building codes in the US. In California, the CalGREEN building code will become effective in 2011 and requires all new buildings to be more energy efficient. CalGREEN also offers additional environmental and health co-benefits in requiring new buildings to be 20% more water efficient, use low pollutant-emitting materials and reduce construction waste (California Office of the Governor 2010). In Seattle, the city resolution sets targets for the energy savings of non-residential buildings at 20% above current ASHRAE Standard 90.1 (REEEP, ASE and ACORE 2010). Other leading policies in building standards include the UK’s Sustainable Homes code, which regulates energy efficiency, carbon emissions, as well as eight other categories of environmental factors such as water efficiency, construction waste and pollution. For China, a leading example of building codes is the requirement of 65% energy savings in more developed provinces and cities such as Beijing and Tianjin (Levine et al. 2010).
Funding sources: building permit fees, development fees, state or national budget allocation, or other new approach

Performance Metric

The performance metric for building codes are the relative level of the codes and levels of compliance.

GHG Emission Reduction Potential

GHG reductions from building codes have included 79.6 Mt CO_2 in the U.S. in 2000 and 35 to 45 Mt CO_2 in the EU. By 2010, Japan’s MEPS is expected to reduce CO_2 by 31 Mt while the U.S would have reduced electricity use by 6.5% with 223.87 Mt CO_2 (IPCC 2007).

Cost Effectiveness

With high GHG emission reduction, building codes are also highly cost-effective. In Hong Kong, 1% of total electricity was saved from building codes while the U.S. achieved 79.6 Mt CO_2 reductions in 2000.

[43] DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2002 on the energy performance of buildings: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:001:0065:0071:EN:PDF

[44] PROPOSAL FOR A DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast): http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0780:FIN:en:PDF

In the EU, building codes have contributed to CO_2 reduction of 35 to 45 Mt and achieved maximum energy savings of 60% in new buildings (IPCC 2007).

4.2.2.2. Appliance standards

Policy Description

National: Another example of efficiency standards used in the building sector is minimum energy performance standards (MEPS) for appliances and office equipment, which has been implemented in many countries including the U.S., EU, Australia, Japan and Korea. Improving the efficiency of energy-consuming household appliances, MEPS can directly reduce the electricity demand of households while providing the same if not better level of service. Reducing electricity demand during peak hours, such as hot afternoons in the summer, appliance standards also have a significant impact in reducing peak electricity load, improving grid reliability while delaying the need to build costly new power plants. Adopting higher standards could also increase demand for more energy efficient products and help move the market toward innovations.

Leading/Reach Standards: California has leading appliance standards that are set beyond the national level. The mandatory state MEPS in California requires the all appliances to meet the voluntary national Energy Star efficiency level.

Funding sources: Government agencies such as the Department of Energy or for states like California, the state provides funding in kind in terms of dedicated full time staff, through Public Benefit Charge funds, and utility companies also provide research and funding support to meet their energy efficiency quota.

Performance Metric

The performance metric for MEPS is the specified efficiency level of the standard for a given product and the compliance rates of products on the market.

GHG Emission Reduction Potential

In California, 31.4% of the state total energy savings were achieved through the appliance standards in 2009 (REEEP, ASE and ACORE 2010). China currently has MEPS for over 30 products, which is expected to reduce CO_2 emissions by 9.1 billion metric tons from 2009 to 2030 under the current revision schedule with 16% lower emissions than the frozen efficiency scenario by 2030 (Zhou et al. 2010).

Cost Effectiveness

With such high emission reduction potential, appliance standards are considered highly cost-effective with costs of -US$15/ton CO_2 in Australia in 2012, -$65/ton CO_2 in the U.S. by 2020 and -$194/ton CO_2 in EU by 2020 (IPCC 2007).

4.2.3. Certification and Labeling Programs

4.2.3.1. Building Certification and Labeling Programs

Policy Description

Building certification and labeling programs may be voluntary or mandatory, and may be categorical, information or endorsement labels. A building energy label or certification provides building owners and tenants, potential owners and tenants and building operations and maintenance staff with information on the building's potential and actual energy consumption. For categorical information buildings labels, building owners and operators can compare their building's energy performance with other similar buildings and evaluate the need for improvements. On the other hand, endorsement labels or green building certification can also allow potential buyers or tenants to differentiate between different buildings and gain insight into the potential long-term costs of building energy consumption. As with other labeling and certification programs, building energy labels are intended to influence the decision-making process of consumers, or building owners and/or tenants in this case, and thereby stimulate demand and market transformation for more efficient buildings. The ultimate effect of the label or certification depends on many factors, such as the use-friendliness of the label, consumers' acceptance and trust of the source of the label, and its relative importance as a decision-making factor for consumers.

Denmark has had mandatory energy labeling of buildings since 1979 with new requirements in effect since 2006 in response to the EU Directive (2002/91/EC) on the energy performance of building. Preparation and efforts have been undertaken to make the issued labels public so that energy companies and other stakeholders can use the information to target their activities. The Danish labeling system exceeds current EU minimum requirements in terms of ambition and extent. Even though the impact of the labeling program is estimated to be high, recent evaluation studies found that the actual savings from the labeling scheme is limited. Although the program is mandatory, it is not well enforced because of the high costs of implementation. The high costs of implementation activities such as inspection and audits are made even more challenging with the lack of public support. For example, many building owners are not interested in the label or the energy information provided by the consultants hired by the government. As a result, only 50% of the family houses applied for the label and a large proportion of new buildings do not have the label (Kiss et al. 2010).

Categorical information labels have been developed in India for office buildings, with a 1 to 5 star rating scale based on actual energy consumption in kWh/m^2/year for participating buildings (India Bureau of Efficiency 2009). In China, categorical labels have also been implemented for demonstrative government buildings. A more popular labeling program for buildings is a voluntary endorsement label, which distinguishes or endorses certain buildings that are more energy efficient than the norm. Existing programs include the U.S. Energy Star label and LEED certification program for green buildings, and the certification of energy efficient passive houses in Germany. Certified green buildings may also have important environmental co-benefits such as water conservation, reductions in construction waste, and effective storm water management which help reduce cost for building owners and reduce burden on municipal infrastructures. Additional co-benefits of green buildings to its inhabitants may include improved health and productivity.

Performance Metric

The performance metrics for both types of building label include label coverage and the efficiency levels set for the rating or endorsement thresholds. For certification programs, the performance metric would be the number of new buildings that have been certified.

GHG Emission Reduction Potential

In Denmark's experience, no natural gas reduction could be found between buildings with and without the mandatory label. This suggests the saving potential is rather small (Togeby et al. 2010).

Cost Effectiveness

The Danish program was not considered cost effective with a high cost of 650 € per label, not including the cost of consultants hired to provide information on the labeling program. However, studies have shown that LEED certified green buildings are cost-effective as green building construction costs, on average, are only higher by 1 to 2% and the investment has one year payback period (Holowka 2007).

4.2.3.2. Appliance Certification and Labeling Programs

Policy Description

As with buildings, categorical information and voluntary endorsement labels also exist for appliances and are more prevalent. The categorical information label provides efficiency information to consumers in the form of estimated average energy consumption and operational cost for a given appliance model and may rate a specific model relative to other similar product models. Examples of existing programs include the mandatory EU and Australia rating energy labels and the U.S. mandatory Energy Guide label. China also has a categorical information label for 19 products to date. Voluntary endorsement labels highlight the most efficient products on the market and include the voluntary Energy Star program used in the US, Canada, Australia and EU, Brazil's PROCEL label and China's voluntary endorsement label for over 40 products.

Performance Metric

For both types of labels, performance metrics are the level of compliance and markets shifts in product efficiency grades after the label was introduced.

GHG Emission Reduction Potential

The categorical label has high GHG reduction potential, with 5 Mt CO_2 savings estimated for Australia from 1992 to 2000. Voluntary endorsement labels have medium GHG reduction potential and are also highly cost effective with 169.6 kiloton of CO_2 reduction in Brazil and 13.2 Mt CO_2 reductions in the U.S. in 2004 (IPCC 2007). On the other hand, in EU, a consumer survey found that although energy consumption and the environment are important factors to the buyers and label awareness is high, other factors such as the price and convenience play a much more important role in purchase decision-making (Togeby et al 2010).

Cost Effectiveness

Mandatory categorical information labels are highly cost-effective with costs of -$30/ton CO_2 reduced in Australia (IPCC 2007). Voluntary endorsement labels are also highly cost effective with savings of US $20 million in the U.S.

4.2.4. . Energy Management

Policy Description

Energy efficiency obligations and quotas are one policy option for promoting improved building energy management and are currently in use in the UK, Belgium, France, Italy, Denmark and Ireland. California also has a Green Building Executive Order S-20-04, which set a 2015 goal of reducing energy use in public and private buildings by 20% of 2003 levels (CEC 2010). Similarly, China's Policy on Energy Management and Government Office Buildings and Large-Scale Public Buildings sets a 20% energy intensity reduction goal for 2006 to 2010 (Levine et al. 2010).

Performance Metric

The performance metric for this policy can be measured in terms of coverage and compliance with the efficiency obligation or quota.

GHG Emission Reduction Potential

This policy has high GHG reduction potential with 1.4 Mt CO_2 emissions reduction per year in the case of UK (IPCC 2007).

Cost Effectiveness

Energy management policies are highly cost-effective with -$216/t CO_2 for households and -$60/t CO_2 for other sectors in 2003 and -$139/t CO_2 in the UK (IPCC 2007).

4.2.5. Promotion of Energy Efficient Technology or Measures

4.2.5.1. Financial Subsidies

Policy Description

As an economic incentive to invest in more expensive but efficient equipment, financial subsidies have been provided to different sectors internationally to promote the purchase and use of energy efficient building technology. In the UK, capital subsidies are provided for investment in qualifying energy efficient equipment while the U.S. provides federal and local (e.g., California Pacific Gas & Electric Utilities) rebates for select efficient Energy Star appliances. In China, rebates have been offered to rural residents for purchasing energy efficient appliances such as air conditioners. China has also offered subsidies for building utilization of renewable technology in forms such as 800-900 RMB/kW for renewable energy applications in buildings in Chongqing and 20 RMB/peak watt of solar PV demonstration projects in buildings (Levine et al 2010). The performance metric for technology-based financial subsidies would be increases in the investment of efficient or renewable energy technologies that were targeted by the subsidies and rebates.

In the U.S., subsidies have also been offered for new building design and construction that exceeds the efficiency requirements in building codes. California's Savings by Design program pays for energy savings that exceed the Title 24 code by at least 10% in the whole buildings or systems approach, while the Efficiency Vermont program help develop energy models for buildings and pay incentives to buildings that exceed the code. Subsidies have also been offered for retrofits in countries like Sweden, Austria, Korea, and the U.S. The city of Fort Collins, Colorado, offers rebates for commercial and industrial customers as part of the city's efforts to achieve its Climate Action Plan goal of reducing its carbon footprint 20% below 2005 levels by 2020 and 80% by 2050. The Business Efficiency Program (BEP) provides services such as assessments, rebates, demand response and technical assistance at no cost to customers, and also provide rebates for adopting efficient technologies such as lighting, windows, cool roofs, insulation, and commercial equipments (REEEP, ASE and ACORE 2010). In China, the Ministry of Housing and Urban-Rural Development and Ministry of Finance jointly released the Opinion on Implementation of Heating System Measurement and Energy conservation Retrofit for Existing Residential Buildings in Northern Heating Areas with a floorspace retrofit target of 150 million m^2 (Levine et al. 2010).

Funding sources: government funds, utility public benefit funds, revolving loan funds.

Performance Metric

The performance metric for financial subsidies vary depending on the products or services being subsidized, but is generally greater consumer uptake and market penetration of the technology being promoted.

GHG Emission Reduction Potential

Financial subsidies have high GHG reduction potential with up to 24% energy savings for buildings in Slovenia, 3.3 Mt CO_2 reduction in UK and 29.1 Mio Btu/yr natural gas savings in the U.S. (IPCC 2007).

Cost Effectiveness

The high GHG reduction of financial subsidies has been achieved at a high cost. In particular, this policy's low cost-effectiveness is evident with social (not end-user) costs of US \$29/t CO_2 and \$41-105/t CO_2 in the Netherlands (IPCC 2007). There are, however, co-benefits to this policy as the savings to end-users can help low-income households reduce their energy costs.

4.2.5.2. Tax Credits and Incentives

Policy Description

Besides direct rebates and subsidies, economic incentives for efficient technology have also been provided in the form of tax credits and incentives in the U.S., France, Netherlands and Korea.
The tax incentives used in the U.S includes (IPCC 2007):

- Industry recruitment incentives: paid to efficient product manufacturers for siting new plants in a state to meet its job creating requirement.
- Production tax credit: provided to the production of a renewable energy system
- Personal tax incentives: given to individuals for installing efficient home improvement measures, purchasing a energy efficient home, or installing a renewable energy system
- Property tax incentives: property tax reductions or limits provided for the installation of energy efficiency measures in homes or businesses
- Sales tax or value-added incentives: for purchase of energy efficient products

For instance, the U.S. has a federal program that provides 10% tax credit for business purchase of efficiency measures while Korea provides 10% income tax credit for energy efficiency investment (IPCC 2007). Oregon's Business Energy Tax Credit (BETC) provides a tax credit for investments in energy efficiency and renewable energy, including building retrofit projects, purchase of efficient products and equipment retrofits. BETC also created a "pass-through option" which allows the government and public buildings that do not owe taxes to the state to transfer the BETC eligibility to another entity in exchange for a lump-sum cash payment upon completion of the project.

Performance Metric

The performance metric for tax credits would also be increases in the sales and adoption of energy efficient technologies.

GHG Emission Reduction Potential

Tax credits and incentives have high GHG reduction potential as evidenced by U.S. savings of 88 Mt CO_2 in 2006 (IPCC 2007).

Cost Effectiveness

These policies are also highly cost effective with overall benefit-cost ratios of 5.4 in commercial buildings and 1.6 in new homes.

4.2.5.3. Technology Dissemination Goals

Policy Description

Technologies can also be promoted through technology dissemination targets or goals, as in California's Solar Initiative (CSI) which set a target of installing 3000 MW of solar photovoltaic (PV) capacity by 2018 and includes $2.9 billion in economic incentives for building owners and homeowners to install solar PV systems (Go Solar California 2010). CSI also includes efforts to promote the use of solar thermal systems and advanced metering in solar applications. Technology dissemination goals are often used in conjunction with fiscal policies, incentives, as well as state/city wide energy efficiency and emission reduction targets.

Performance Metric
The performance metric for technology dissemination goals would be the extent to which the promoted technology diffuses into the market.

GHG Emission Reduction Potential
The emission reduction potential depends largely on the technology being promoted and the dissemination rates that result from the goal.

Cost Effectiveness
The cost-effectiveness of technology dissemination goals depend on if complementary policies such as financial incentives or fiscal policies are used to support the goal and the cost of those policies.

4.2.5.4. Cooperative Procurement

Policy Description
Cooperative procurement in which two or more companies enter into a joint purchasing agreement to maximize economies of scale and thereby reduce the unit cost of efficient equipment has been used throughout Europe and Japan.

Performance Metric
The success of cooperative procurement agreements can be gauged by its coverage and compliance rates.

GHG Emission Reduction Potential
The energy and GHG reduction potential of cooperative procurement arrangements can vary but a German telecommunications company achieved energy savings of up to 60% for specific units (IPCC 2007).

Cost Effectiveness
There are no additional costs to this program as the energy efficient purchases are made with funds that would have been used anyway.

4.2.5.5. Zoning

Policy Description
Zoning at the city or county level is another measure that can promote efficiency as illustrated in California's Smart Land Use plan of focusing on transit-oriented development. By promoting jobs and

housing in close proximity and encouraging high density residential/commercial development along key transit corridors, important transport energy savings and CO_2 reductions can be achieved.

Moreover, in Boston, Massachusetts, a green building zoning code was implemented in 2007 to reduce emissions from privately owned and operated buildings throughout the city. This zoning code requires all major construction projects exceeding 50,000 ft^2 to meet the U.S. Green Building Council's LEED certification standard. However, the building codes itself is under the jurisdiction of the state and the city of Boston has less flexibility to change the codes. Therefore the city changed the city zoning coded which it has direct control over through the Zoning Commission. Under this change, a number of notably green buildings that have featured south-facing glass walls for passive heating and cooling as well as renewable technologies have been constructed.

Performance Metric

The performance metric for zoning programs would be the area coverage of the zoning regulation and the overall stringency of the zoning requirements.

GHG Emission Reduction

After the implementation of the green zoning code, construction projects such as the Audubon Nature Center in Boston have resulted in 30 to 35% energy savings compared to traditional construction (Boston Redevelopment Authority 2009).

4.2.6. Public Sector Leadership

Policy Description

The public sector can play an important role in demonstrating new energy efficient technologies or practices by setting more ambitious goals or targets for its buildings. This approach is used by local governments in the US to demonstrate the feasibility and benefits of energy efficiency and renewable energy standards. States that have had difficulty implementing more stringent codes often adopt the standards for public buildings as a manageable first step. Experiences gained and lessons learned can then be shared with other building owners to promote the adoption of the codes statewide. New York City is implementing strategies to improve the energy performance of its own buildings and fleets by 30% over the next decades (REEEP, ASE and ACORE 2010). California's Green Building Executive Order S-20-04 also sets an ambitious 2015 goal of reducing energy use in public buildings by 20% of 2003 levels.

New Mexico State in its Executive Order 2007-053 set a goal for all state agencies to reduce their buildings' operational energy intensity (per square foot) by 20% below the 2005 level by 2015. The U.S. also passed a law requiring new federal buildings to be designed with 30% greater efficiency than building code requirements. China's policy on Energy Management of Government Office Buildings and Large-Scale Public Buildings also calls for energy intensity reductions of 20% between 2006 and 2010 (Levine et al. 2010).

Funding source: government budget, grant, private foundations, utility programs and energy performance contracts.

Performance Metric

The performance metric of public sector leadership include meeting the program's stated goal or target, such as a given % reduction in energy intensity or CO_2 emissions.

GHG Emission Reduction Potential

Public sector leadership has high GHG reduction potential with Germany achieving 25% reduction of CO_2 in the public sector over 15 years (IPCC 2007).

Cost Effectiveness

Public sector leadership also has high cost-effectiveness, with U.S. estimates of $4 savings per $1 of public investment (IPCC 2007). The New York Municipal Building Code estimates that $2.3 billion over 9 years will be required to achieve its 1.68 million ton of emission reduction target, which implies $152/year/ton of emission reduction. The cost for the upgrade of public buildings averages 1.5% of construction cost, and the energy upgrades pay for themselves on average in seven years (REEEP, ASE and ACORE 2010).

4.2.6.1. Government Procurement

Policy Description
Similar to co-operative procurement amongst businesses, government procurement can accelerate the market penetration of efficient appliances as one of the largest consolidated buyer of building equipment and often the largest consumer of energy. The U.S. federal government has a mandatory procurement program for Energy Star products and similar procurement programs also exist in Japan, Korea, and Mexico. China also has a government procurement program for products with the voluntary endorsement label.

Performance Metric
These procurement programs can be evaluated on the basis of whether the energy information is clear and accessible and the overall compliance level of mandatory procurement programs like the U.S.
GHG Emission Reduction Potential
The GHG reduction for government procurement programs can be high, with four cities in Mexico saving 3.3 kiloton CO_2 in one year, 20 to 44 Mt CO_2 potential in the EU and expected reduction of 3.6 Mt CO_2 from China's program (IPCC 2007).

Cost Effectiveness
Government Procurement programs' cost-effectiveness will vary, but has been in the medium range with savings of $726,000 per $1 million purchases in Mexico and expected cost under $21/t CO_2in the EU (IPCC 2007).

4.2.7. Other Building Policy Instruments and Tools

4.2.7.1. Public Benefit Charges

Policy Description
Public benefits charges are surcharges added to a customer's utility bill to fund public purpose programs such as educational initiatives, low-income utility assistance and often environmental and efficiency programs. The surcharge is usually a very small share (e.g., 2.5% to 5%) of a utility customer's total energy bill and is collected and managed by local utilities, regulatory agencies or public interest organizations. In the U.S., many states have public benefit charges and these charges have been used to fund building efficiency programs such as low-income weatherization programs in California and the Building Efficiency program in Oregon. Specifically, the Energy Trust of Oregon's building efficiency program uses a 3% public benefits charge to fund financial incentives and technical design assistance for efficiency improvements in new construction or major renovation projects (Nexus Market Research Inc. 2005).

Performance Metric
The performance metric for public benefit charges are often total energy savings under funded programs or cost-benefit ratios of these program.

GHG Emission Reduction Potential

In Oregon, the public benefit charge has resulted in medium GHG reductions with saving of 5.9 aMW and 135,500 therms from 796 projects in 2004 (Energy Trust of Oregon 2010).

Cost Effectiveness

The public benefit charges have had high cost-effectiveness at cost s ranging from –US \$53/t CO_2 to -\$17/t CO_2 (Nexus Market Research Inc. 2005).

4.2.7.2. Building Audits

Policy Description

Building auditing is a tool that is often used in conjunction with other policies to measure and verify actual energy savings in building efficiency improvements.

National: It may be required in building certification programs such as Energy Star and U.S. LEED ratings. Leading Program: Finland is considered to be a leading country on energy audits because all companies and municipalities have joined the country's Voluntary Energy Efficiency Agreement. Through this agreement, stakeholders are committed to carrying out energy audits by undertaking analysis of their own energy consumption and energy saving potential as well as developing an action plan for implementing cost-effective efficiency measures. These audits are particularly significant as it relates to the national implementation of the EU Directive and studies have found the auditing program in Finland to be very successful. The factors for success identified in Finland's program include a) a flexible planning approach, b) a clear vision of objectives and central elements of the policy instrument, c) active promotion of the policy instrument, d) training of auditors, e) co-operation and dialogue with stakeholders, f) interlink policy instruments, g) flexible and competent implementing agency, h) long-term political support, and i) systematic and thorough monitoring (Kiss et al. 2010). This policy instrument serves as a good example of "learning by doing" for countries that are planning to implement a similar energy audit program.

Performance Metric

A performance metric for building audits would be the total number of audits conducted.

GHG Emission Reduction Potential

Building audits can result in significant GHG emission reduction if the results of audits are addressed through the installation of energy efficiency measures. In the U.S., for instance, the weatherization program has saved an average of 22% for audited and weatherized households (IPCC 2007).

Cost Effectiveness

Building energy audits have medium cost-effectiveness but can be more effective if combined with other measures such as financial incentives for implementation of efficient measures. The U.S. weatherization program had a benefit-cost ratio of 2.4 (IPCC 2007).

4.2.7.3. Information Dissemination and Data Sharing

Policy Description

In building efficiency information dissemination and data sharing, conducting surveys and compiling results in databases are useful tools that have been in use in the U.S. Specifically, the U.S. Department of Energy has a Commercial Building Energy Consumption survey database with results of sample surveys conducted every four years and a Residential Energy Consumption database with survey results from over 4000 households (EIA 2010). Besides surveys, other information tools include the U.S. Energy Star's benchmarking program and international awareness and information campaigns in Denmark, Britain, Canada, Brazil and Japan.

Performance Metric

The performance metric for information tools include the availability and dissemination of the survey data through websites and brochures and accessibility of the tool or database.

GHG Emission Reduction Potential

As indirect tools, information dissemination and data sharing have had low GHG reduction potential as seen in Britain's Energy Efficiency Advice Centres having annual savings of 10.4 kt CO_2 (IPCC 2007).

Cost Effectiveness

However, the cost-effectiveness of information dissemination and data sharing has been high with – US$66/t CO_2 in Brazil and average cost of US $8/t CO_2 for all programs in the British Energy Saving Trust (IPCC 2007).

4.2.7.4. Public Recognition and Awards

Policy Description

Another popular policy tool for promoting voluntary efficiency initiatives is public recognition efforts or awards that reward successful efficiency initiatives. Japan has an annual Energy Conservation Grand Prize that recognizes personnel, organizations and products and systems within sectoral subcategories while the U.S. also has annual Energy Star awards that recognize organizations that have made outstanding contributions to energy efficiency. China has also launched a manufacturer promotion program to recognize manufacturers of efficient equipment.

Performance Metric

The performance or impact of public recognition and awards are inherently difficult to measure, but can be generalized as increased motivation in energy efficiency efforts.

4.2.7.5. Promotion and Support for Energy Service Companies (ESCOs)

Policy Description

As companies that offer energy services to building owners and operators with guaranteed energy savings and/or provide energy service at lower cost by taking on responsibility for energy efficiency efforts, Energy Service Companies (ESCOs) have been promoted by many policies as a key way to delivery efficiency improvements. The U.S. ESCO market is considered mature with US $2 billion revenue in 2002 but ESCOs are also active in Europe, Japan, India and Mexico (IPCC 2007). In China, ESCOs are also being promoted as Premier Wen Jiabo chaired a State Council executive meeting on March 17, 2010 to discuss policies and measures to accelerate the development of ESCOs and energy management contracting (China Climate Change Info-Net 2010). This meeting emphasized that China will actively promote mechanisms that facilitate energy management contracting and ESCO services in design, retrofits and operation management for companies, public institutions and other users.

Funding sources: In the private sector, ESCOs pay for themselves over time. Government agencies could pay for ESCO projects by securing a loan from a private lending institution or by issuing bonds, or to finance public projects through the use of lease financing. For local government, the lease can be viewed as an ongoing operating expense which has a dedicated revenue stream rather than as a capital budget item (REEEP, ASE and ACORE 2010).

Performance Metric

The performance metric of efforts to promote ESCOs can be the size of the ESCO market measured in terms of revenue or financial activity.

GHG Emission Reduction Potential

ESCOs have high GHG reduction potential with building energy savings of 20 to 40% in Finland, 3.2 Mt CO_2 reduction per year in the U.S. and expected reduction of 40 to 55 Mt CO_2 by 2010 in the EU (IPCC 2007).

Cost Effectiveness

ESCOs have medium cost-effectiveness with mostly zero cost in the EU and costs of under \$22/t CO_2 in other countries. In the U.S., ESCOs have achieved benefit-cost ratios of 1.5 in the public sector and 2.1 in the private sector (IPCC 2007). Successful promotion of ESCOs can be measured by the levels of publicity and media promotion and have co-benefits in increased competitiveness amongst ESCOs.

4.2.7.6. Energy Reporting

Policy Description

Reporting of detailed billing or end-use energy consumption data and disclosure programs are another important building efficiency policy option and is in use in Italy, Sweden, Japan, Finland, Norway and the U.S. In the U.S., reporting and disclosure requirements are often associated with specific programs such as the Energy Star program, which requires manufacturers of labeled products to report annual sales.

Performance Metric

The performance metric for reporting would be coverage and data availability, and the success of reporting programs have depended on its combination with other measures and periodic evaluation.

GHG Emission Reduction Potential

Successful energy reporting programs have shown reduction potential of up to 20% energy savings (IPCC 2007).

4.2.8. Carbon or Energy Tax

Policy Description

Taxes have been used in the EU to limit and reduce energy consumption and its related CO_2 emissions. By directly imposing a tax or economic penalty on a unit of energy consumed or CO_2 emitted, the market failures in promoting energy efficiency and conservation are addressed with a price placed on energy consumption’s environmental externalities. In order to achieve the same level of energy service without having to pay more energy taxes, consumers will seek out energy efficient measures and practices.

In Denmark, an energy tax was introduced for households beginning in 1977 and more recently, a CO_2 tax was introduced to all sectors in 1996. Currently, the highest tax for electricity consumption is paid by households and the public sector, with electricity taxes corresponding to 0.09 €/kWh plus 25% VAT. There is also a high tax for heating energy across all sectors, although energy intensive companies pay the lowest tax. The total revenue from energy taxes is 5 billion €, of which half is derived from the transport sector (Togeby et al 2010).

Performance Metric

The performance metric for energy or carbon taxes include the level and coverage of the tax, and whether there are significant variations between sectoral consumers.

GHG Emission Reduction Potential

Studies have shown that without the energy taxes, Denmark's total energy consumption would be at least 10% higher than its actual levels (Togeby et al. 2010). In Sweden, evaluations of energy taxes show that the resultant price increase in electricity between 1991 and 2001 resulted in a 5% reduction of energy consumption.

Cost Effectiveness

Carbon or energy taxes are highly cost effective as the cost of implementation is relatively low on the government side and GHG and energy reductions can be substantial. However, there can be societal and end-user costs to energy and carbon taxes if the taxes are not structured properly (i.e., tiered rates by income or total consumption).

4.2.9. CO2 Cap or Quota

Policy Description

A cap on CO_2 emissions limits the amount of CO_2 emissions that can be emitted from energy using or generating equipment. In 2008, the European Union GHG Emission Trading Scheme (ETS) added a CO_2 cap on energy installations above 20MW, which includes generation and district heating, as well as industrial installations. By limiting the CO_2 emissions and forcing energy installation owners to pursue efficiency and mitigation measures, the cap essential raises the price of energy. For end-users, the ETS functions as a European wide energy tax. The price of CO_2 by March 2010 is 13€/ton CO_2 and it has increased the electricity price by 0.01€/kWh for all users.

Performance Metric

The performance metric for CO_2 caps include the relative stringency of the cap and its coverage as both determine the subsequent increase in energy prices.

GHG Emission Reduction Potential

The GHG emission reduction potential is directly linked to the relative level of the cap, as a stringent and enforced cap will result in significant emission reductions. Alternatively, a lax or unenforced CO_2 cap will not have emission reduction potential.

Cost Effectiveness

CO_2 caps are very cost effective from the government's perspective as the costs to implement are relatively low compared to the reduction potential. However, there can be costs to end-users and society in general so overall cost effectiveness will vary by program.

4.3. Transportation Actions

In many developing countries, transport is a rapidly growing sector with motorization and urbanization growing at a steady pace. Rapid growth and high oil dependency has increased the growth rate of carbon emissions, and thus increased the need for policies and efforts to control the rise in emissions. This chapter introduces national and city-level low-carbon transportation policies that are effective in supporting the goal of continued economic flexibility and growth while stabilizing and reducing carbon emissions in the transport sector. Sustainable development policies and measures (SDPM), a policy approach that aims to meet domestic objectives while bringing significant benefits to the climate through GHG emission reductions, have been developed to provide a long-term low carbon and flexible transport strategy (Bradley et al. 2005). Some specific policies and efforts which are described in more detail below include: encourage greater use of walking and bicycling, develop efficient public transport, green vehicles, build and enhance high efficiency city transport infrastructure, and appropriately price transport fuels and options. These policies must be integrated and the impacts on different vehicle types and land uses, as well as decision-making choices and rebound effects (e.g., raising fuel economy increases vehicle use) must all be considered.

4.3.1. Target Setting

Policy Description

Similar to the CO_2 emissions target setting for other sectors, the transport sector also needs to set a cap for the target year. As is the case for rapidly growing countries or markets, although total passenger or freight transport is growing rapidly, it is possible to have a better understanding of future transport emissions trajectories through reasonable planning and modeling projections. A low-carbon transport framework provides policymakers with the option to select from many low-carbon policies and measures in setting the target. In light of uncertainties in the future, the CO_2 emissions target is also an instructive goal and not a mandatory target.

As research has shown, expanding existing policies to raise the overall fuel economy in the UK can reduce emissions by 5% from 1990 levels by 2020. If more aggressive measures are undertaken, then emissions can be reduced by 15% from 1990 levels by 2020 (UK Department of Transport 2009).

Performance Metric

The CO_2 emissions target is indicative of the effectiveness of transport policies.

GHG Emissions Reduction Potential

The emission reduction potential can be determined by comparing the emissions of a business-as-usual (BAU) scenario where no CO_2 target is set and there are no associated policies and measures undertaken in the future with the projected emissions after implementing a CO_2 target and related transport policies.

Cost Effectiveness

There are some implementation costs related to setting a CO_2 target for the transport sector.

4.3.2. Standard Setting

4.3.2.1. Fuel Economy Standards

Policy Description

In addition to price signals, a fuel economy standard is a tool that can be used to promote the production of fuel efficient vehicles by manufacturers. This policy is usually set through regulatory or political means and mandates the average fuel consumption per unit of distance traveled, such as miles per gallon in the U.S. or kilometers per liter in Europe and Asia. Fuel economy standards can be implemented using different measures, including corporate (sales-weighted) average (U.S. former), fleet average (EU), weight-based (China), size-based (Korea) or vehicle footprint-based standard (U.S. revised). Table 18 summarizes fuel economy standards in multiple countries and Figure 12 shows a comparison of major national fuel economy standards in the world. Fuel economy standards help drive technological improvements to reduce fuel consumption by inducing innovation in vehicle technologies.

Because fuel taxes can be set too low to promote sustainable transport choices, fuel economy standards can play an important role in reducing GHG emissions. Because consumers do not consider fuel costs in vehicle purchase decision-making, a mandatory standard can help address this market failure. The standards inherently reduce CO_2 emissions by improving fuel efficiency and reducing the fuel burned, but there are no direct incentives for reducing the GHG content of the fuel (Gallagher et al. 2007). Compared to other policies promoting fuel efficient vehicles, fuel economy standards are also more politically attractive and create certainty about the minimum fuel efficiency of new motor vehicles. However, fuel economy standards also have weaknesses in that they do not address the scale effect or the age effect of continued operation of older inefficient vehicles and do not induce innovation beyond the standard. In the absence of price signals, fuel economy standard may not affect driving behavior but may actually increase travel activity (i.e., the rebound effect may be observed).

Table 18: International Fuel Economy and GHG Emission Standards for Vehicles

Country/region	*Type*	*Measure*	*Structure*	*Test Method*	Implementation
United States	Fuel	mpg	Footprint-based value curve	US CAFE	Mandatory
California	GHG	g/mile	Car/LDT1	US CAFE	Mandatory
European Union	CO_2	g/km	Weight-based limit value curve	EU NEDC	Voluntary for now, Mandatory by 2012
Japan	Fuel	Km/L	Weight-bin based	Japan 10-15/JC08	Mandatory
China	Fuel	L/100-km	Weight-bin based	EU NEDC	Mandatory
Canada	Fuel	L/100-km	Cars and light trucks	US CAFE	Voluntary
Australia	Fuel	L/100-km	Overall light-duty fleet	EU NEDC	Voluntary
Republic of Korea	Fuel	Km/L	Engine size	US CAFE	Mandatory

Source: Adapted and updated from Table 2 of Feng An and Amanda Sauer (2004). Comparison of Passenger Vehicle Fuel Economy Standards and GHG Emission Standards around the World.

Source: An et al. 2011.

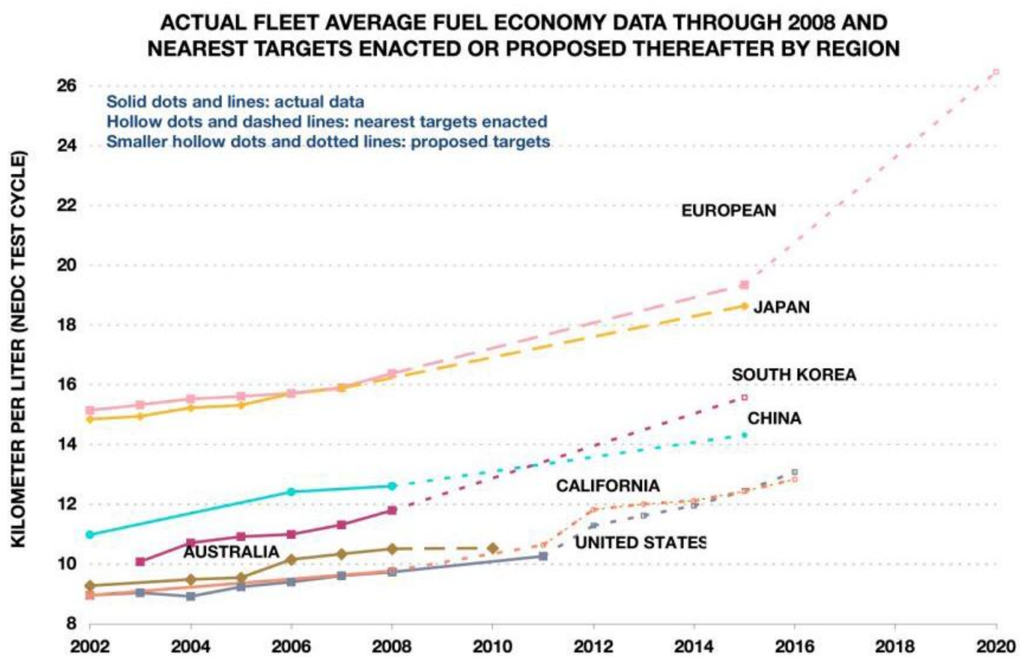

Figure 12. Comparison of Proposed International Fuel Economy Standards

Source: ICCT 2009.

Performance Metric

The performance of fuel economy standards can be measured by the stringency of regional, national, state or provincial, and city-level fuel economy standards, taking into consideration the different basis for setting standards. Although fuel economy standards are usually national standards, other local governments (provincial, city) can also set fuel economy standards that are more stringent than national standards.

GHG Emissions Reduction Potential

Fuel economy standards can reduce carbon emissions through reduced fuel use. The emission reduction potential depends on the improvement in fuel economy and carbon content of the fuel.

Cost Effectiveness

New high efficiency vehicles, such as hybrid gas-engine and electric-motor vehicles, presently have a higher capital cost than less efficient models. However, the energy savings over the lifetime of the vehicle yield fuel cost savings, which vary depending on local fuels prices and the distance driven.

4.3.2.2. CO2 Emissions Standard

Policy Description

CO_2 emissions standards or GHG performance standards are similar to fuel economy standards except that the standard defines the tailpipe GHG emissions resulting from the combustion of fuel, rather than fuel consumed, for distance traveled. In most cases, the standard is defined in terms of mass of CO_2 equivalent per distance, such as grams CO_2 equivalent per kilometer or mile traveled for new vehicles and shares many of the same advantages and disadvantages as fuel economy standards. In addition, a GHG performance standard helps incentivize reduction of all GHGs from motor vehicles, including non-CO_2 GHG such as methane and nitrous oxide (Gallagher et al. 2007). At the same time, these standards also help create positive incentives to reduce oil consumption and increase fuel efficiency, as less fuel consumed translates into lower emissions.

In April 2009, the EU adopted new vehicle standards that would reduce the average CO_2 emissions from new cars to 95 g CO_2/km by 2020. Over the short-term, the standard also includes a target goal of 130 g CO_2/km for 2012 with mandatory compliance by 2015.

Performance Metric

CO_2 emitted per distance traveled and compliance rates with standard are performance metrics that can be measured.

GHG Emissions Reduction Potential

The 2020 target under the EU CO_2 standard is a 40% reduction in CO_2 emissions from 2007 levels. In the UK, the standard is expected to reduce CO_2 emissions by 7 million tons of CO_2 annually in 2020 (UK Dept of Transport 2009).

Cost Effectiveness

There are relatively low implementation costs related to CO_2 emissions standards.

4.3.2.3. Low Carbon Fuel Standard

Policy Description

As a different kind of GHG emissions standard, California's low carbon fuel standard (LCFS) applies to transport fuels produced by oil refineries and distributors as well as importers. Jet fuel and some bunker fuel are excluded from the law because of the lack of regulatory authority and logistical challenges that arise. California's LCFS limits the total carbon and other GHG emissions per unit of fuel oil consumed by setting deadlines for compliance with an intensity reduction target. The standard covers the lifecycle emission of fuels, including extraction, cultivation, land use change, processing, transport and distribution, as well as final use. Although the upstream GHG emissions account for only 20% of total emissions from petroleum, it is nearly the equivalent of total lifecycle emissions from biofuels, electricity and hydrogen fuel (Sperling and Yeh 2009). As the development of climate polices accelerate, California's LCFS represents a major push as the first lifecycle-based regulation.

Implementation of the LCFS requires that each fuel supplier meet stringent emission intensity reduction goals (e.g., California's LCFS requires 10% reduction by 2020). In order to provide flexibility and promote innovation, LCFS allows for trading of emission credits among fuel suppliers to meet the standard. For example, oil refiners can sell emission credits to biofuel producers or they can buy credits from electricity producers that reduce emissions by providing power to electric vehicles. By combining command and control and market mechanisms, LCFS is more robust and sustainable than purely command and control measures and is also more acceptable and effective than purely market mechanisms. Companies that fail to meet the standard will be faced with fines or legal sanctions (e.g., sanctions are imposed by the state government through the California Air and Resources Board in California).

In parallel with California's LCFS, the EU proposed a LCFS and the subsequent Fuel Quality Directive (EC 2008 FQD) was officially adopted in December 2008 by the European Parliament. The FQD requires energy suppliers to reduce GHG emissions by 10% by 2020. The EU requirement is broader than the 10% California LCFS because it includes upstream gas and emissions, carbon capture and sequestration (CCS) technology and CDM projects under the Kyoto Protocol in emission credit purchases. Upstream emissions, CCS and CDM can be used to meet 4% of the 10% reduction requirement.

Performance Metric
Percentage reduction in fuel carbon intensity relative to baseline fuel is a performance metric for this measure.

GHG Emissions Reduction Potential
The emission reduction potential is dictated by the level of the fuel standard and scope of coverage, as illustrated by the 10% reduction mandated under the California and EU standards.

Cost Effectiveness
This policy has associated government Implementation costs and may increase the cost to fuel suppliers.

4.3.3. Expand Public Transportation

Public transportation and mass transit play important roles in helping reduce CO_2 emissions from local transportation, specifically by providing a lower carbon transport alternative to personal vehicle use and through the introduction of more efficient "green" buses.

Policy Description
Policies to reduce transport CO_2 emissions through public transportation (particularly buses, as urban light rail is described further below) focus on increasing the use of public transportation as well as promoting a shift towards more efficient and low carbon bus fleets. Various policy measures can be undertaken to increase the public transportation share of total transit activity including: low fares and simplified fare payment (e.g., centralized travel card), higher levels of service and route coverage, and increased quality of service through competitive bidding process for all services. London, for instance, adopted an integrated policy package including many of these measures which have resulted in a 62% increase in passenger use and 36% increase in kilometers traveled by bus (Buchan 2008). Rebate and subsidy programs can also be launched to promote the use of public transportation, such as discounts for students and senior citizens and value passes for frequent users. The UK even goes as far as to offer free bus transit for elderly and disabled residents during off-peak hours and on weekends and holidays.

In addition, providing convenience to transit users through enhanced integrated fare systems and real time travel information can help further increase mass transit ridership. In Singapore, for instance, ridership continued to increase after 2001 with continued expansion of the rail transit network and introduction of contactless smart cards that can be used for public bus fares, light rail transit, and even non-transit applications (Sun 2007).

An emerging policy for mass transit is bus rapid transit (BRT) in dense cities which can provide frequent, fast and direct services to easily accessible locations with low costs and flexible routes. This requires establishing high-capacity, high-speed transit corridors and minimizing the number of transfers needed while ensuring it is part of an integrated multi-modal system (EF 2011). In China, Guangzhou introduced its BRT in February 2010 and it is integrated with bike lanes, metro and other local bus routes. The Guangzhou BRT now moves 27,000 passengers/hour/direction during peak times (EF 2011).

Besides increasing the utilization of buses through improved access and quality, CO_2 emissions can also be reduced directly through increased fuel efficiency and greater penetration of hybrid, electric, and fuel cell technology. The fuel efficiency of bus fleets can be improved by encouraging fuel-efficient operation through greater passenger loads as more passengers translate into lower emissions per passenger and also by incentivizing the adoption of low carbon buses. Low carbon buses can play a greater role in the bus fleet through mandating the purchase of newer hybrid buses to replace older inefficient buses (e.g. San Francisco Muni) or by providing incentives for hybrid buses. In the UK, the Bus Service Operators Grant (BSOG), a scheme that refunds some of the fuel duty incurred by operators, was revised to provide higher subsidies of additional 6 pence per kilometer for hybrid buses as well as 3% increase in refund for operators that can improve efficiency by at least 6% over the previous two years (UK Dept of Transport 2009).

Performance Metric

Performance metrics for this policy include public transit share of total transit activity, bus loads (passengers/hour/direction), and fuel economy and emissions intensity of buses.

GHG Emissions Reduction Potential

Hybrid buses can reduce CO_2 emissions by 30-40% compared to conventional buses, along with 95% less particulate matter and 40% less NO_X.

Cost Effectiveness

Most of the funding for public transit and buses is from government sources. However, the higher capital costs of hybrid buses (up to $150,000 in the case of San Francisco) are expected to be recovered over the lifetime through increased fuel economy and lower maintenance costs (SFMTA 2011).

4.3.4. Urban Light Rail Transit

Urban light-rail transit comprises a large share of total urban transport (including metro, suburban railway, and light-rail) and uses a specialized light rail or railway system separated from other public roads (World Bank 2001). Compared to other non-road public transport modes such as public buses, taxis, or paratransit, the railway system has higher carrying capacity and performance. Internationally, the word “metro” usually refers to metrorail or subway system and heavy rail transport, but it can also refer to elevated rail systems. It has the highest capital cost per kilometer of transport among large, high-speed transport modes, but it also has the highest carrying capacity (Wright 2003). The metro railway is considered to have the smallest environmental footprint and thus the most environmentally friendly. Suburban and urban rail transit is different from light-rail transit (LRT) because it usually has heavier passenger loads and longer distance trips than LRT and is connected to the interregional rail systems (Wright 2003). Light rail transit is characterized by a single electric rail car or shorter trains operating on dedicated ground path, elevated high speed light rail, metro rail or occasionally a path on the ground.

Policy Description

Urban light rail should be introduced in cities with high population density. The European experience has shown that in cities with populations of over ten million, urban light-rail transit can have important effects reducing CO_2 emissions and improving the efficiency of urban transport. Ideally, urban light rail transit should be initiated in cities where it can reach a capacity of 10,000 or 20,000 persons per hour per direction (pphpd), with the greatest impact if capacity can exceed 35,000 pphpd.

Nevertheless, urban light rail transit has also received criticism primarily focused on its relatively low cost-effectiveness with high initial capital costs and high operating costs. For developing countries in Asia, different solutions – rather than a single solution - should be chosen based on different characteristics, objectives, pricing strategies, and financing mechanisms. In many cases, transport problems can be addressed not by only one new technology, but rather by a portfolio of technologies and the optimal carrying capacity. If the contributions of urban light rail are considered from a life-cycle perspective, then it is the choice with the lowest capital costs.

Policies that support light rail transit including increasing the proportion of light rail transit in total transport activity in the planning and development of urban light rail systems. Chinese mega-cities such as Beijing and Shanghai have set a long-term development target of more than 1000 km light rail transit. In the process of developing local urban development plans, governments should consider light rail transit and take steps to incorporate it into transport and infrastructure planning and development.

Performance Metric

Performance metrics for this policy include the total distance of light rail and light rail transit's share of total transport activity.

GHG Emissions Reduction Potential

As the research results of NDRC Energy Research Institute (ERI) have shown, urban transit has 80% lower CO_2 emissions per capita than private car transport[45].

Cost Effectiveness

There are high initial capital costs but the life-cycle averaged capital costs are relatively low and provide a significant contribution to urban transit system.

4.3.5. Urban Planning and Non-motorized Transport

Non-motorized transport includes walking and bicycling, which are transport modes with zero-emissions, and are the most important low carbon transport choices. Bicycles have historically held high shares of total transport activity but its share along with the share of walking has declined rapidly with the shift towards private cars and deteriorating conditions and environment for walking and bicycling. However, both modes of non-motorized transport have emerged in advanced economies as goals of protecting

[45] Through personal communication with Kejun Jiang at the ERI.

the environment have corresponded to greater use of bicycles for transport. At the same time, these countries have continuously improved the infrastructure for pedestrian and bicycling activity.

Policy Description

Non-motorized transport should be promoted as an important element of urban transport development through planning, target setting, and infrastructure development. Policies that can help promote the shift towards non-motorized transport include improving access, convenience, and safety of cycling and pedestrian activity. More specifically, different policies and programs can be initiated to increase the use and subsequent travel share of cycling and walking.

As a viable alternative to short car trips, cycling can directly offset the carbon and other air pollutant emissions from driving along with providing additional benefits of improving health and reducing congestion. One important policy area for increasing the use of bicycles to reduce auto dependence is by creating bike-friendly networks through urban design. Specific design considerations can include providing designated bike lanes on all streets, limiting automobile access to bike areas and lanes, and separating pedestrian and bike areas with barriers to maximize safety (Calthorpe 2011). Providing secure bike parking in buildings, on streets and at transit stations also helps encourage cycling (EF 2011). The establishment of shared bicycle rental programs such as the Yellow Bike Project in Portland, Oregon and the Paris VELIB program along with government-funded cycling demonstration towns and cities such as those in the UK can also help increase awareness and use of cycling for personal transport.

Complementary to policies that support cycling, policies and urban design considerations can also help encourage pedestrian activity and thereby reduce emissions from car trips. Specifically, buildings and local communities can be designed to promote pedestrian convenience by lining sidewalks with retail, benches, shades, street lighting, and other amenities; providing frequent entries at sidewalks, limiting block lengths, and/or allowing for pedestrian access through existing superblock developments (EF 2011). Similarly, designing local streets with lower speed limits help emphasize pedestrian safety and reducing setbacks and blank walls at street edges to enhance security (Calthorpe 2011).

Performance Metric

The share of bicycle lanes/paths of total road area, total length of pedestrian walkways, and bicycling as share of total transport activity can be used as performance metrics for non-motorized transport.

GHG Emissions Reduction Potential

With zero emissions, non-motorized transport can help offset emissions by reducing the trips taken in cars. The cycling demonstration program in the town of Exeter in the UK has reported 9% of employees cycling regularly to work and biking contributing to 20% share of all trips taken by students and school staff. Similarly, three Sustainable Travel Towns in the UK have reported 9% reduction in car trips resulted by 14% increase in walking and 12% increase in cycling (UK Dept for Transport 2009).

Cost Effectiveness

This policy has relatively low capital costs. The UK invested 50 million pounds over three years to launch 18 cycling demonstration towns and cities (UK Dept for Transport 2009).

4.3.5.1. Transport Demand Reduction through Spatial Planning

Land use planning has important impacts on transport demand as expanding the physical scope of work, commercial, and residential spaces increases travel distance and makes public transport less useful and efficient. In contrast, spatial planning design emphasizing high density, mixed use communities can help foster greater biking and pedestrian activity while improving convenience. These principles have been adopted under the UK's plan for smart growth, which follows a "Proximity Principle" that advocates higher density, self sustainability, and walkable communities (Buchan 2008).

In China, national planning regulations already require local governments to consider the impact on transport when making planning decisions. For example, China's 2007 Climate Change Plan set key goals that include supplementing existing planning policies with sustainable transport and reducing private vehicle use (NDRC 2007c). This objective has also been evident in other planning policies, including regional development strategy guidelines and national port, network and airport development polices. This is also part of the implementation and policy reform process in the 2008 national planning framework, and must also be considered in climate change adaptation and mitigation guidelines. For new and emerging cities, more specific spatial planning design considerations and measures can be adopted to reduce the need for transportation. Some recommended design considerations and policies are discussed below.

A key design for reducing city traffic congestion is to create dense networks of streets and paths that can help maximize passenger mobility rather than vehicle throughput. This may include varying block size and street design to provide multiple options for different types of traffic including non-motorized transport and dispersing high traffic volumes over narrow, parallel routes rather than wide boulevards (EF 2010). One recommended option for reducing traffic congestion is to increase the use of one-way couplets, one-way roads with opposing traffic flows that are typically found in densely populated cities such as San Francisco, New York City, Toronto, Seattle and Denver. These roads enable more bike lanes, shorten crossing distance and thus signal times and overall travel times can be reduced with more direct access and shorter block lengths (Calthorpe 2010).

Additionally, creating zones, neighborhoods, blocks, and districts with mixed commercial and residential use can help increase local destinations and eliminate the need for longer-distance travel. Clustering key daily destinations such as shops, schools, parks and public services help enable pedestrian activity for workers and residents alike by providing incentive and convenience to walking. Likewise, open space such as neighborhood and regional parks should be integrated into planning with walkable distances to promote walking (Calthorpe 2010). Complementary to these spatial designing principles are additional policies that can concurrently discourage the use of cars. This could include limiting the total number of permitted parking spaces in new developments and charging fines for parking over the limit in existing developments.

Since there are design principles, it is inherently difficult to quantify the performance, emission reduction potential, and cost-effectiveness of reducing transportation demand through spatial planning.

4.3.6. Fiscal Policies

Policy Description

Fiscal policies and tools can help influence behavior change to reduce the use of motorized vehicles and increase the adoption of non-motorized transport and typically include tax rebates, subsidies, and pricing schemes. Often, fiscal policies intended to promote greenhouse gas emission reduction do not seek to generate revenue but rather, attempt to return a portion of the individual or company's income so that the total tax revenue does not increase. Other fiscal measures promoting low carbon transport may include strategic infrastructure funding for projects that reduce VMT, road and congestion pricing, and car purchase incentives and trade-in programs (Moorhouse and Lemphers 2009). Two specific examples of common fiscal policies for low carbon transport including fuel pricing or fuel taxes and congestion pricing are examined below.

4.3.6.1. Fuel Pricing

Fuel prices will have an important impact on vehicle utilization. In Indonesia, the share of public transport is very low even for low income cities, with some cities having only a 5% share of public transportation. This is linked to the fact that Indonesia's fuel subsidies have had a negative effect on increasing the use of private transport, especially motorcycles, which resulted in public transport having a very low share of total transport activity (EST 2010). Appropriate fuel prices can be an effective strategy for saving energy and reducing emissions. Despite relatively low implementation costs and existing fuel taxes in many districts, they face strong opposition from the oil industry and are politically difficult to implement. This is especially a challenge for countries such as Egypt and Yemen where oil production dominates the national economy. In recent years, countries in other regions including Morocco, Tunisia, and Ghana have served as good role models with reasonable fuel prices. In addition, there is also the challenge of relatively low price elasticity of demand for gasoline, which may lead to insufficient response to gasoline price increases.

From an economic perspective, the higher economic burden of potential fuel taxes on consumers can be offset in other areas such as income or other tax relief so that the increased cost is transferred to the economy as a whole. Higher energy taxes can reduce oil consumption and reduce dependence on oil producers while encouraging industry to use fewer, more efficient resources to increase productivity, innovation, and overall development. In contrast, lower energy prices would encourage the waste of resources and hurt the economy overall.

Based on extensive research, some recommended principles for increasing fuel prices include (GTZ 2009; Durning and Baumann 1998):

- Raise fuel tax to improve overall transport quality, not only road conditions, so that there is greater accessibility to more efficient alternatives

- Revenue from new taxes should reduce personal and corporate taxes, transferring the basis of taxes from "good consumption" to "bad consumption"
- Tax increases should be gradual and foreseeable, such as 10% increase per year, thereby allowing consumers and companies to take higher cost into consideration when making long-term decisions related to housing and vehicle use
- Provide tax relief to low income and other vulnerable populations
- Tax all possible harmful products (with fewest exception as possible) in order to ensure credibility for the tax
- Transparent and open communication with the public to ensure the principles and reasoning behind the policy is understood

Fiscal policy and public finance can play a very important role in reducing the transport sector's CO_2 emissions. They can achieve CO_2 emissions reduction by encouraging the purchase of high fuel efficiency vehicles, providing incentives to encourage fuel efficient behavior, and through other low-carbon transport options.

Performance Metric
Performance metrics for this policy include the scope and coverage of fiscal policy and the level of tax or subsidy.

GHG Emissions Reduction Potential
The UK's announced fuel tax increase of 2 pence per liter in September 2009 and 1 pence per liter per year from 2010 to 2013 is expected to reduce CO_2 emissions by 2 million tonnes by 2013-2014 (UK Dept of Transport 2009).

Cost-Effectiveness
The implementation costs of fiscal policies and measures are usually relatively low. There may be additional costs to consumers or society (e.g., from taxes) but these can be offset by other fiscal policies such as income tax relief.

4.3.6.2. Congestion Charges

Congestion pricing policies impose higher charges on travelers at times and places with high levels of congestion to change traveler behavior and provide congestion relief. By imposing an additional cost through a congestion charge, travelers are provided economic incentives to travel during off-peak hours, through non-congested routes or through other modes of transportation (Timilsina and Dulal 2008). From an economic perspective, congestion charges can be an effective transport policy because they internalize the social and environmental costs of road congestion. However, critics have also pointed to congestion pricing's potentially disproportionate effect on the welfare of low-income groups. In these cases, revenue redistribution and investment of revenue generated by congestion pricing in public transportation have been recommended to help mitigate the disproportionate impacts. London, for instance, is required by law to invest all net revenue generated by its congestion pricing program in improving transport.

Congestion pricing measures have been adopted by different countries and states, including Singapore, Norway, the U.S., and London in the UK. The pricing schemes differ, with daily charges incurred by motorists in Singapore and the UK while the U.S. and Norway charge a toll per passage. Specifically, Norway has charges for toll rings while the U.S. has high occupancy toll lanes in southern California, Maryland, Texas, and Minnesota. By paying a toll charge, a single occupant vehicle can travel on express high-occupancy lanes. In London, vehicles entering a specific downtown zone were required to pay a congestion charge ranging from £9 to £12 (with lower charges for paying a day ahead or automatically) between the peak travel hours of 7AM to 6:30PM on weekdays (Transport for London 2011). In Singapore, the pricing scheme changed in 1998 from per day charges to per entry charges using electronic road pricing or electronic toll collection. The electronic road pricing consists of a complex pricing scheme where the charges vary by vehicle, time of day and point of entry and the prices are reviewed every three months (Santos et al. 2004).

Performance Metric

Reduction in traffic in target zone, modal shift to public transport, annual reduction in car mileage can be used to measure the performance of congestion charges.

GHG Emissions Reduction Potential

Congestion pricing can have an important impact on reducing GHG emissions if it effectively reduces transport and promote modal shifts to low carbon public transport. In London, for example, city-center traffic was reduced by 12%, of which more than half was shifted to public transport. In addition, vehicle distance traveled across London was also reduced by 211 million km per year with a £5 charge (Timilsina and Dulal 2008). If London's congestion pricing scheme was implemented in New York, studies estimate 9% daily traffic volume reduction in the city. Another study show that congestion charging by distance in Copenhagen could reduce annual car mileage in Copenhagen by 7%, with resulting annual CO_2 emissions reduction of as much as 154 million tons possible (Rich and Nielson 2007).

Cost-Effectiveness

Congestion pricing results in net economic benefit rather than cost because the revenue generated by the congestion charges often exceeds operating costs. In Singapore, the annual operating cost of the electronic toll collection was 3.75 million Euros, compared to annual revenue of 35 million Euros in 1998. In London, net revenues of £148 million resulted from the program during 2010 to 2011 (Transport London 2011).

4.3.7. Technological and Other Measures

4.3.7.1. Green Vehicles

Green vehicles, typically hybrid or all electric vehicles can be used as taxis or office vehicles to lower the GHG emissions of vehicle trips. Many cities currently have green taxi programs. The Chinese Ministry of Science and Technology has also launched a 1000 clean energy vehicle program in ten cities.

Policy Description

In New York, neighborhood electric vehicles (NEV) provide another option for short distance intracity travel. Wireless technology helps promote the deployment of electric vehicles and wireless charging as a potential way to provide strong and effective battery storage for electric vehicles which can further help solve the energy storage issue. Fuel cell technology can also provide a new solution for the development of fuel-based vehicles. In general, regulatory support and economic incentives can help pave the way for the development of green vehicles.

In San Francisco, California, for example, in consultation with the taxi commission, the city environmental protection agency issued a "green taxi law". The law lists the 2012 city target of reducing carbon emission by 20% from 1990 levels as a vehicle target for taxis. The guide also provided details on the funding and incentives for these green cars. Beginning on June 1, 2011, every taxi fleet will need to ensure that their greenhouse gas emissions meet the target of 20% reduction from 1990 levels by 2012 jointly set by the environmental protection agency and the taxi commission (Newsom 2010).
The UK government Car and Dispatch Agency (GCDA) also has a "Green Cars" program that uses conventional hybrid cars for its taxi service to government and public sector clients. Similarly, the UK has also set targets for government agencies to purchase cars that meet the 2012 CO_2 emissions standard by 2010-2011 (UK Dept of Transport 2010).

Performance Metric

The performance metric for this policy is the share of green vehicles in the vehicle fleet.

GHG Emissions Reduction Potential

Hybrid, all electric, or fuel cell vehicles have lower GHG emissions compared to fuel-based vehicles. The emission reduction potential depends on the size of the fleet and type of vehicles, with reported reduction of 50% in the UK Green Cars program when compared to traditional black cabs and 20% reduction from 1990 levels in San Francisco's program (UK Dept of Transport 2010; SFMTA 2010).

Cost Effectiveness

The initial cost of "green vehicles" may be higher but could be recouped over the vehicle's lifetime with fuel savings.

4.3.7.2. Education and Awareness

Educating drivers about energy-saving driving techniques and patterns can help reduce vehicle emission by 10-15%, as demonstrated by the UK's Eco-Driving program (UK Road Safety Ltd. 2010). In addition, freight transport and logistics industries can also promote behavioral change among truck drivers by imposing fines. This can help increase safety awareness, as well as reduce fuel costs and road emissions. In the UK, the one-day Safe and Fuel Efficient Driving (SAFED) training program was initiated in 2003 with government funding and has since trained 12,000 heavy goods vehicle (HGV) truck drivers as well as 7500 van drivers.

In the EU, the rail and ocean freight industry has initiated a project to promote optimal driving behaviors by making recommendations based on the effectiveness of fuel consumption and emission reductions. Recently a study has been conducted to assess and analyze the project's biggest carbon emission reductions potential and how to achieve the savings potential.

Performance Metric
Performance metrics include the number of participants in training programs and the actual reduction in fuel consumption.

GHG Emissions Reduction Potential
The UK SAFED driver training for van drivers has resulted in 16% fuel consumption reduction on the day of training and 5% reduction overall (SAFED 2008). The SAFED demonstration program for bus drivers is estimated to deliver potential fuel efficiency improvements of 8-12% (UK Dept of Transport 2010).

Cost-Effectiveness
Funding for the UK SAFED program for bus drivers is 1 million pounds. In addition to emission reductions, driver training programs can also have benefits in fuel savings.

4.3.7.3. Transportation Demand Reduction through Technology

Many employers allow telecommuting, which provides a way to change lifestyle travel choices. However, research has shown that telecommuting does not necessarily result in a lower carbon footprint, so further assessment is needed. Many central and regional governments also provide online services, thereby reducing residents' need to travel to obtain government services. The Internet has also changed the way consumers shop. Although online shopping increases the transport needs for product delivery, there can be overall efficiency gains compared to the use of private vehicles for shopping trips. This also helps reduce passenger transport trips. Government efforts and measures can include promoting working from home such as small office/home office (SOHO), teleconferencing, online procurement, online banking, nearby public service and procurement centers, and changing the types of vehicles deployed.

Some possible policies and measures include:

- Shorten commute: promote work from home or at a telework center to reduce transportation needs for commuting
- Meetings: teleconferences and video conferences can help reduce the transportation needs for holding meetings
- Shopping: Online shopping can reduce transportation needs. This will require effective freight transportation logistics and organization, which can help reduce aggregate transport demand.
- Banking: online banking can reduce transportation needs.
- Service Payments: online payment systems or payment stations at major banks and convenience stores can help reduce transportation needs.
- Public services: Postal, legal filing and public tendering can be conducted online or via telephone to eliminate the need for in-person visits.

Performance Metrics

Performance metrics for this policy include the use of online services and % employees or share of time telecommuting

GHG Emission Reduction Potential and Cost-Effectiveness

As relatively new and undefined measures, there is very limited quantification of the GHG emission reduction potential or the cost-effectiveness of reducing transportation needs through information technology.

4.4. Power Sector Actions

4.4.1. Target Setting: Renewable and Non-Fossil Fuel Targets and Utility Quota Obligations

Policy Description

Voluntary or mandatory renewable targets are often expressed as a share of total electricity production, installed capacity, primary or final energy consumption or in some cases as absolute installed capacity by technology type. Currently, 98 countries including over 40 developing countries have renewable energy targets with target years ranging from 2010 to 2020. After the EU achieved its 2010 targets for wind, solar PV and heat pumps, a baseline renewable target was set at 20% share of energy by 2020. However, some member states such as Finland and Sweden have already met their 2020 goals while others have adopted more aggressive targets (Figure 13). For example, Germany recently passed revisions to the Renewable Energy Sources Act of 2012 that require at least 35% of renewable energy in the electricity supply by 2020, 50% by 2030 and 80% by 2050 (Sustainable Business 2011). China currently has technology-specific installed capacity targets by 2020 as well as a 15% share of total primary energy consumption target for non-fossil fuels (including nuclear) by 2020.

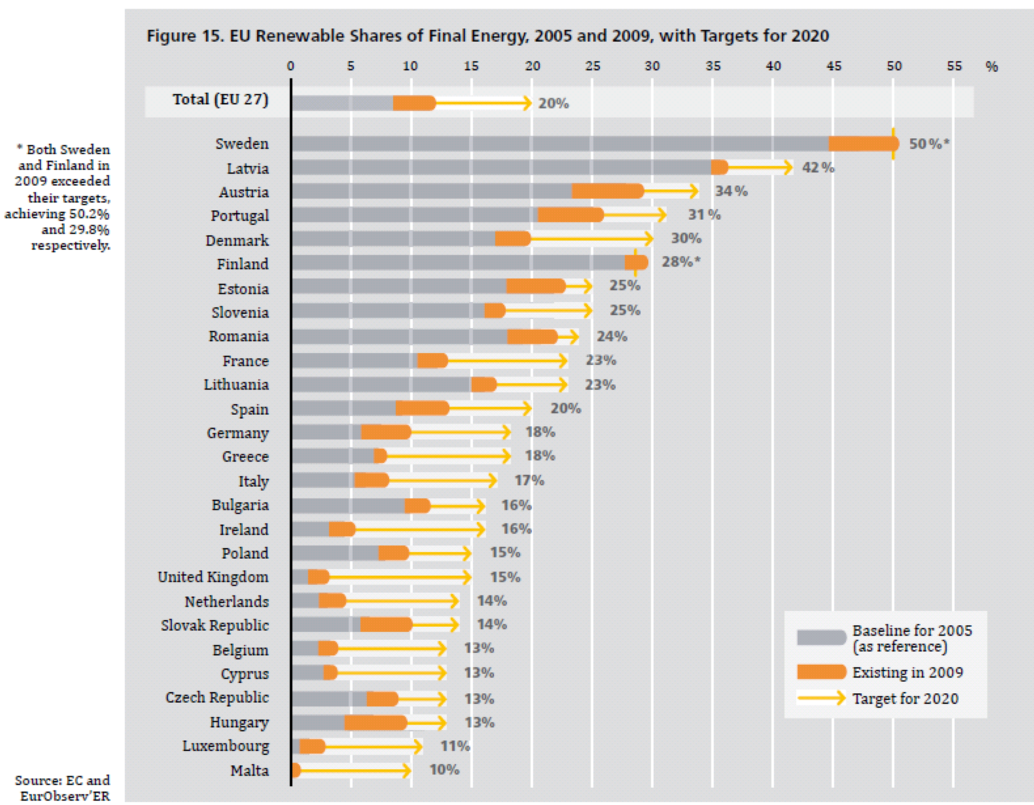

Figure 13: Renewable Shares of Final Energy in the EU: 2005 - 2020

Source: REN21 2011b.

Besides national renewable targets that help signal support and provide certainty for expanding renewable industries, countries or states/provinces can also set a minimum quota for renewable energy generation for utilities. This quota, sometimes known as a Renewable Portfolio Standard (RPS), is generally expressed as a minimum percentage of power generation sold or capacity installed that must be from renewable energy sources. There are currently 9 countries with national quotas, including Australia, Italy, Japan, Poland, Romania, Sweden and the UK and 4 countries with state or provincial quotas including 38 states in the U.S. (REN21 2011a; DSIRE 2011).

Performance Metrics

Performance metrics include installed capacity by technology and share of total installed capacity/power generation/primary or final energy consumption on national or local levels.

GHG Emission Reduction Potential

Renewable energy sources are carbon neutral in power generation and the extent of total GHG emission reduction depends on the existing fuel mix of power generation.

Cost-Effectiveness

Implementation costs do occur with setting renewable targets but specific data on these costs are limited.

4.4.2. Economic and Financial Measures

4.4.2.1. Feed-in Tariffs

Policy Description

Feed-in tariffs are policies that help encourage grid price parity for renewable energy by setting a price that is guaranteed over a timeframe for power producers to sell the electricity generated from renewable sources to the grid. Feed-in tariffs typically include three components:

- Guaranteed grid connection for renewable energy sources
- Long-term contract for renewable energy producers
- Purchase price or additional fixed premium based on cost of generation

Feed-in tariffs can apply to regional and national grid electricity from renewable options (solar, wind, tidal, biomass, hydrogen and geothermal electricity generation). Currently, 45 countries have national feed-in tariffs and 4 countries including the U.S. have state or provincial feed-in tariffs (REN21 2011a). China has also set regional feed-in tariffs for nuclear, wind, and other renewable energy including solar PV and biomass. Recent changes include a move towards categorized feed-in tariffs for renewable electricity based on technologies and conditions of renewable energy resources (Ma 2011). In July 2011, China also set the first unified benchmark solar feed-in tariff at 1 yuan per kWh for projects approved after July 1 and 1.15 yuan per kWh for projects approved before July 1 and completed by the end of 2011 (Liu 2011). China is expected to double its 2010 installed capacity of 0.9 GW by the end of 2011 and achieve a target of 10 GW by 2015.

Performance Metrics

Performance metrics include the level of the tariff in terms of national currency per kWh or MWh generated, the duration of the tariff, and subsequent addition of renewable power to the grid.

GHG Emission Reduction Potential

Renewable power is carbon neutral and the increased generation resulting from feed-in tariffs can offset or reduce power generated from fossil fuel sources. The extent of total GHG emission reduction depends on the existing fuel mix of power generation.

Cost-Effectiveness

There are some implementation costs associated with feed-in tariffs but there is limited specific data on these costs.

4.4.2.2. Power Purchasing Agreements

Policy Description

Power purchase agreements (PPAs) are similar to feed-in tariffs in that they guarantee purchase of energy or capacity from an electricity generator/provider over a period of time. However, a PPA is more specific in that it serves as an actual legal contract between the power purchaser and an independent, non-regulated power producer. Advantages of PPAs include tax incentives or credits for renewable power generators, a fixed long-term electricity price for both parties, and operation and maintenance responsibilities for the buyer (Shah 2011). PPAs have been used by different states in the U.S. and sometimes by national agencies to meet their renewable targets.

***Performance** Metric*

Performance metrics for this policy include the scale of generation, contract price, and length of time of contract.

GHG Emission Reduction Potential

The GHG emission reduction potential for this policy is the same as that outlined above for renewable power generation.

Cost-Effectiveness

There are some transaction costs associated with setting up a PPA but specific data are not available.

4.4.2.3. Renewable Energy Certificates

Policy Description

Renewable energy certificates (RECs) are tradable certificates that represent every kWh or MWh of renewable energy generated and allow consumers to meet their renewable energy obligations through trading or purchasing of these certificates from renewable energy producers. Similar to GHG emissions credit trading, these certificates can provide flexibility for meeting renewable targets by separating the physical attributes of renewable electricity from their embodied attributes (e.g., carbon neutrality). Effective REC trading systems can also help expand the market for renewable power generation by increasing competition and lowering costs among renewable power producers capable of generating RECs. Additionally, RECs can help promote growth in the renewable market and facilitate compliance with renewable targets or standards because RECs are not subject to geographical and physical limitations of renewable electricity generation. At the same time, the effectiveness of RECs trading also depends on the ability to track and verify REC transactions and the overall liquidity and price transparency in the market (Holt and Bird 2005).

RECs are currently used on a national level in 20 countries including Australia, Japan, Russia, Norway, and many of the EU member countries as well as by states in the U.S. (REN21 2011a). The European Energy Certificate System (EECS) also enables the issuance, transfer and redemption of voluntary RECs with 209 TWh of certificates issued in 2009. Similarly, Japan's RECs market also reached 227 TWh of certificates with 50 sellers in 2009 (REN21 2011b). In the U.S., 14 of the initial 18 states with RPS policies allowed RECs to be used to meet RPS compliance (Holt and Bird 2005).

Performance Metric

Performance metrics for this policy include the volume of RECs sold, the price of RECs, and the number of RECs sellers.

GHG Emission Reduction Potential

The GHG emission reduction potential for this policy is the same as that outlined above for renewable power generation.

Cost-Effectiveness

There are some transaction costs associated with RECs trading but there are also important economic advantages that may not be directly captured by economic accounting practices. Specifically, trading enables renewable energy generation to become more cost-effective by overcoming the physical constraints of renewable energy production.

4.4.3. Generation Policies

4.4.3.1. Coal-fired Generation Standards

For coal-abundant countries such as China and Australia, regulatory policies have been implemented to improve the efficiency of coal-fired power generation. These policies include mandatory closure of older, small inefficient coal-fired power plants and energy or emissions standards for new coal-fired units.

Policy Description

In China, the 11th Five Year Plan for 2006 to 2010 set a closure and upgrading target of 50 GW of capacity for the mandatory closure and replacement of small coal-fired plants with large units. By July 2010, China surpassed its original goal with total closure of 70.7 GW of small-scale coal-fired units. This policy provided incentives for the closure of small units by encouraging enterprises to undertake mergers, acquisitions, or restructure with small coal-fired plants before approving large unit construction (Lin et al. 2010).

To directly raise the process efficiency of coal-fired power plants, China's NDRC also requires new power plants to install super-critical or ultra-supercritical coal-fired units. This policy can also be enacted on a provincial or city-level, with higher generation efficiency standards set to reflect local environmental and economic development targets.

In Australia, fossil fuel generator efficiency standards were introduced in 2000 and aim to move fossil fuel generators towards best practice energy efficiency. The 2004 standards set legally binding, five-year best-practice efficiency standard of 42% net thermal efficiency for black coal (higher heating value) and 31% net thermal efficiency for brown coal (higher heating value) (IEA, 2010). In addition, beginning in 2011, all new power plants must meet emission standards with reference to a "best practice" technology –specific standard (Harris 2011).

Performance Metric

Performance metrics in clued the closed inefficient coal-fired power plant capacity, average thermal efficiency of coal-fired units, and emissions intensity of coal-fired units.

GHG Emission Reduction Potential

The emission reduction potential for mandatory closures of inefficient units depends on the efficiencies and emissions intensities of the inefficient units and the replacement units. One estimate suggests that reduction of 13.6 Mtce and 27 Mt CO_2 were achieved through the closure of 9 GW of capacity in China (RAP 2008). For efficiency or emissions standards, the emission reduction potential will depend on the current fleet efficiency.

Cost-Effectiveness

As with most standards, closure of inefficient plants and efficiency standards for coal-fired generators can be very cost-effective in reducing the power sector's GHG emissions.

4.4.3.2. Generation Dispatch Order

Policy Description

Generation dispatch policies which set dispatch rules and revise priority dispatch order can also influence the future electricity generation fuel mix and reduce GHG emissions. This has been seen in European countries such as Germany and Denmark, where electricity from clean renewable sources are given priority dispatch compared to traditional fossil fuel electricity generation. In most existing electricity systems, however, electricity dispatch is usually cost-based following economic dispatch where the lowest marginal cost generation is dispatched first and does not take environmental factors such as emission intensity into consideration.

In China, dispatch in the power sector has historically followed an “equal shares” formula where generators of a given type are guaranteed approximately the same number of operating hours to ensure sufficient revenue for cost recovery (Kahrl et al. 2011). Unlike cost-based dispatch, this equal shares dispatch is not only environmentally unsound but also economically inefficient as generators with high heat rates and low efficiency may receive the same number of hours as more efficient units with low heat rates. The lack of incentives for efficient and cleaner power generation build-out and dispatch is beginning to be addressed by China with the State Council issuing the “Detailed Rules for Implementing of Energy Saving Generation Dispatch” in 2007. This rule modifies the dispatch order to one based on environmental impacts (as measured primarily in terms of emissions) and thermal efficiencies of the units (RAP 2008). Under this order, the operation of non-emitting resources such as renewable energy, hydro and nuclear generation is prioritized before low-emitting units such as natural gas and high-emitting coal-fired units. Trials of this new dispatch order are being conducted in some provincial grids before being implemented on a national basis (Liu et al. 2010). This dispatch order favors efficient generation and will help drive investment towards renewable and efficient power generation.

Performance Metric

The performance metric for this policy is the adoption of dispatch rule based on environmental impacts.

GHG Emission Reduction Potential

The total reduction potential will depend on the additional use of renewable power and displaced inefficient power generation.

Cost-Effectiveness

Dispatch rules can reduce environmental costs, particularly with environmental monitoring, as online thermal monitoring is built in to thermal power generating units in China’s case. However, the overall costs and benefits are difficult to quantify.

4.4.4. Fiscal Incentives

Policy Description

This type of policy focuses on reducing the cost and increasing the market competitiveness of renewable energy technologies, including: capital investment assistance, third-party financing, investment tax and property tax breaks, production tax credit, sales tax rebates, tax credits and others (REN21 2011a). These incentives can be funded by government or even through taxes levied on fossil fuels, which will help increase the competitiveness of renewable energy while also addressing environmental and energy security externalities.

Specific examples of financial incentives and measures include (REN21 2011a):

- Investment subsidies, grants and rebates: the government provides a one-time subsidy or compensation for a certain percentage of the capital investment cost.
- Tax incentives: tax incentives introduced through fiscal policies all have a common goal of providing tax relief for renewable energy production.

Clement et al. (2005) provides overview of specific tax incentives for renewable energy projects, including:

- Investment Tax Incentives: income tax deduction or credit for some fraction of the capital investment made in renewable energy projects or costs of renewable energy systems installed on residences and businesses.
- Production tax credit: income tax deduction or credit for renewable energy producers at a set rate per kWh of generation
- Property tax reduction: reduction or elimination in property tax for owners of land or real property used for renewable energy production
- Value-added Tax Reduction: exempts renewable energy producers from taxes on value added between purchase of inputs and sale of outputs
- Excise (Sales) Tax Reduction: exempts renewable energy equipment purchasers from a percentage of excise or sales tax for the purchase of renewable energy equipment
- Import Duty Reduction: reduces or eliminates import duties on imported equipment and materials used for renewable energy production facilities

Many countries have implemented various forms of tax incentives as stated above and seen in Figure 14, including: Austria, Denmark, Finland, Netherlands, Germany, Hungary, Italy, Luxembourg, Norway, Spain, Sweden, Switzerland and the UK, along with New Zealand, China, India, Philippines, Canada, Japan and the U.S. Within the U.S., different states have also offered investment tax incentives, property tax reductions and excise tax reductions for renewable energy. Detailed tables of the specific levels of fiscal measures by jurisdiction can be found in Clement et al., 2005.

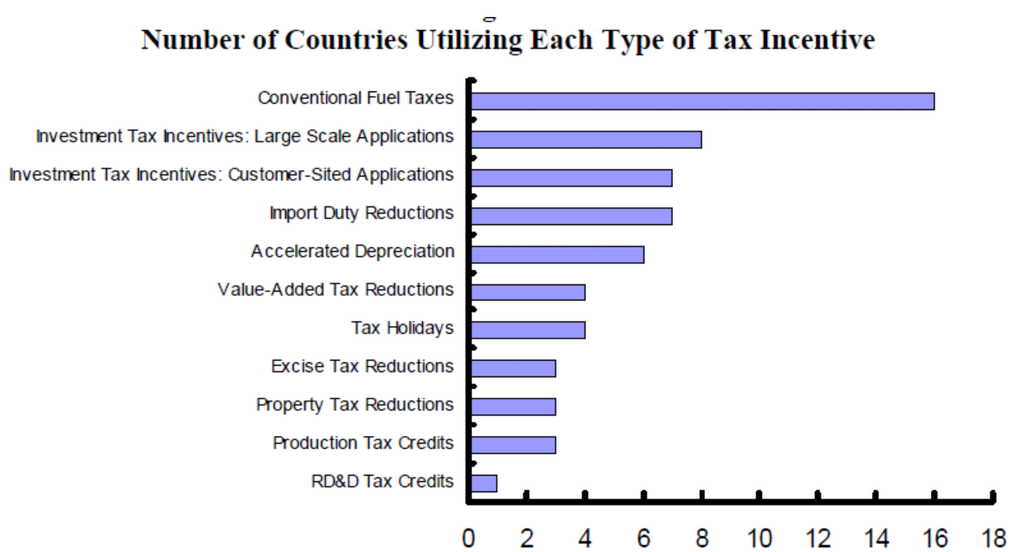

Figure 14. Use of Tax Incentives in Different Countries

Source: Clement et al., 2005.

Extensive international experience has revealed certain factors for success in incentive program design and implementation (Clement et al. 2005). First, the effectiveness of the tax incentives in influencing renewable energy investment and consumption decisions depends on whether the size, scope, and time length of the tax incentive is of sufficient scale. Second, these incentives and policies must be tailored to the developmental stage of the renewable energy industry and change accordingly to reflect industry development. Third, interactions with other government policies and energy market conditions along with other supportive policy initiatives or measures should be considered when designing the tax incentives.

Performance Metrics

Performance metrics in clued the size and use of tax incentives and the development of renewable energy industries as indicated by total capital, number of enterprises, production capacity, and generation.

GHG Emission Reduction Potential

Besides the direct impact of incentives in increasing the utilization of renewable energy, it is difficult to quantify GHG emission reduction potential of these incentives as they are one of many factors in the decision-making process.

Cost-Effectiveness

Fiscal incentives require government funding and are the most cost-effective if supported by complementary policies and measures. The exact cost-effectiveness will vary by policy depending on the size, scope and length of the measure.

4.4.5. Electricity Pricing Scheme: Block Pricing, Time of Use Pricing

Electricity prices are often set as part of a complex rate setting process that is determined by jurisdiction and regulatory structure of the electricity market. In general, the price of electricity is based either on the costs incurred to provide the service if the market is regulated and administered based on the cost of service or set based on competitive market prices if deregulated (NAPEE 2009). The complexity of electricity price setting has been illustrated in the case of China, where both wholesale generation prices and retail prices have undergone reform since the 1990s. Generation prices have evolved from being based loosely on average cost to include a coal priced adjustment mechanism along with regional benchmark prices and facility-based prices for renewable and nuclear and hydropower, respectively (Kahrl et al. 2011).

Retail electricity prices have also increased gradually and on average are now comparable with the long-run marginal cost of supply, but still fall short of representing each customer class's cost of service. In particular, social and affordability considerations have resulted in residential and agricultural electricity prices being below the estimated marginal cost while industrial and commercial sectors face higher costs (RAP 2008). Additionally, interruptible and time-of-use pricing have also been introduced for industrial and commercial consumers but less so for residential consumers. For the residential sector, inclined block pricing and time-of-use (TOU) pricing are two common differential pricing policies that can be introduced to promote energy savings and GHG emission reduction. An additional pricing policy for industry, differential pricing based on industrial energy efficiency, is discussed in the Industrial Policies section of this report.

4.4.5.1. Inclining Block Rates

Policy Description

Inclining block rates, also known as inverted block rates, are an example of a fixed-rate category designed to provide customer incentives for energy efficiency by making incremental consumption beyond a minimum block of kWh consumption more expensive. Specifically, the inclining block rates include a basic customer charge (regardless of usage) and a fixed volumetric rate for the first usage block (e.g., the first 200 kWh consumed). For subsequent blocks of electricity consumed, the fixed volumetric rates become increasingly higher and thereby send a price signal to customers to moderate additional usage. Inclining block rates can be applied to all consumer classes and provide high customer incentive for energy savings as well as medium customer incentive for peak demand savings (NAPEE 2009). However, their effectiveness also depends on consumers' general awareness of the pricing scheme and their ability to recognize and act on the price signal. In the U.S., inclining block rates have been adopted in five states including California, Delaware, Maryland, Oregon and Vermont along with the District of Columbia.

Performance Metric

Performance metrics include the reduction in energy demand after implementation of inclining block rates, the level of block rates, and allowable consumption under each block.

GHG Emission Reduction Potential

It may be difficult to determine the exact emission reduction from reduced energy consumption as a result of inclining block rates due to various other factors that may impact usage.

Cost-Effectiveness

The cost-effectiveness is difficult to ascertain given challenges in determining the GHG emission reduction.

4.4.5.2. Time-of-Use Pricing

Policy Description

As with inclining block rates, Time-of-Use (TOU) electricity pricing is also intended to send a price signal to consumers to reduce energy consumption at certain times of usage. In most cases, TOU pricing sets electricity prices for a specific time period in advance, with lower off-peak prices and higher peak prices aimed at shifting power loads from peak to off-peak periods. In some cases, critical peak pricing utilizes TOU pricing only on certain peak days, with prices intended to reflect the actual cost of generation or wholesale electricity purchase price. If load shifting is successful, TOU pricing can help eliminate power shortages and increase the overall efficiency of the power sector by reducing or postponing the need for new capital investment and reducing the load factor of peaking coal-fired power plants (RAP 2008). A related form of time-based pricing is real-time pricing, which reflects the actual cost of electricity during specific hours of the day and year with the same price signals to incentivize load shifting. However, its effectiveness is more difficult to assess due to major variations in pricing schemes and their secondary effect on energy efficiency.

In the U.S., 315 power providers offered TOU rates in 2008 with rates adopted in 23 states and Washington DC. In China, TOU pricing for industry has led to significant on-peak/off-peak price differentials ranging from 3:1 to 6:1, providing strong price signals for encouraging load shifting (RAP 2008). TOU pricing can also be adopted for residential consumers, where higher peak prices can encourage investment in high-efficiency air conditioners (typically used during peak periods) or behavior change to shift usage of dishwashers or clothes washing and drying to off-peak periods (NAPEE 2009).

Performance Metric

Performance metrics include the reduction in electricity consumption during peak periods and the peak load rate.

GHG Emission Reduction Potential

TOU pricing is typically associated with peak energy demand reductions on the order of 3-6% for fixed TOU pricing and 13-20% for critical peak pricing (Faruqui and Sergici 2010). In addition, short-term energy savings of 3.3% to 7.6% have also been reported (NAPEE 2009). As peak generation is typically coal-fired or fossil-fuel based, there is some incremental GHG emission reduction from reducing peak demand.

Cost-Effectiveness

Although the incremental GHG emission reduction from TOU pricing will depend on load shifting versus energy savings and thus cost-effectiveness of GHG emission reduction may vary, TOU pricing is cost-effective in improving the efficiency of the power sector.

4.4.6. Demand Side Management

Demand side management (DSM) refers to the funding and/or implementation of a broad array of targeted tools for promoting energy efficiency through modification of end-use electricity consumption by utility or state-designated entity. DSM programs aim to reduce either overall consumption through energy efficiency or to reduce peak demand through load management and demand response initiatives. Similar to TOU pricing, load management through demand response can be effective in reducing peak demand and thereby reduce the need for costly new construction, but may not achieve all cost-effective demand-side potential. DSM energy efficiency programs can tap into different measures and tools targeted at promoting energy efficiency.

DSM has been adopted by utilities and more than 30 countries, including the U.S., Australia, the EU as well as Thailand and Vietnam. In China, DSM has been evaluated by different Chinese provinces and cities as an option for power sector management in recent years. For example, DSM pilot programs and activities have been initiated in Shenzhen, Beijing, Shanghai and Jiangsu, and Henan provinces since the mid-1990s with emphasis on demand response programs of TOU and interruptible load pricing and end-use efficiency projects for large energy consumers. DSM has also been mentioned in various national policies and documents.

4.4.6.1. DSM Energy Efficiency Programs

Policy Description

DSM energy efficiency programs can be designed and implemented in various ways, and may include any or all of the following energy efficiency measures (NRDC 2003):

- Financial incentives to end-users to modify energy use or switch to more energy efficient equipment (e.g., efficient appliance rebates, recycling programs)
- Entering into energy efficiency performance contracts or other third-party initiatives
- Educating end-users on available efficiency opportunities (e.g., free or subsidized home audits, public energy efficiency awareness campaigns)
- Developing suppliers or end-use energy products and services (e.g., energy service companies or ESCOs)

In the U.S., for example, more than 500 utilities implemented DSM programs between 1985 to 1995, and total spending increased to $1.1 billion in 2000 (NRDC 2003). Most of the utility programs in the U.S. are funded by a "public benefits" or "public goods" surcharge on customer utility bills, where the charge is a very small percent (<5%) of the total electricity and gas charges. A successful example of DSM has been in California, where funding for utility DSM programs increased substantially after 2001 and includes funding from a public benefits charge. A 2003 study found that California's programs spent US$893 million in 2001 to save 3389 MW of summer peak demand and 4760 GWh of annual energy use (Global Energy Partners 2003).

Performance Metric

In California, the performance of utility DSM programs has to be analyzed using four measures of cost-effectiveness from different perspectives, including (Meade 2010):

- Total Resource Cost test: evaluates whether the program improves economic efficiency in a broad sense
- Utility Cost test: includes utility expenditures on program administration, including marketing expenses and incentive payments, in the calculation
- Participant test: measures the program's impact on participating customers by measuring the change in month utility bills, adding incentive payments and subtracting participation fees and equipment costs incurred by the customer
- Rate Impact Measure test: measures the program's impact on average rates

The specific performance metrics used for each of these tests are shown in Table 19 below.

Table 19 Performance Metrics of Different Types of Cost-Effectiveness Tests

Primary	Secondary
Participant	
Net present value (NPV) (all participants)	Discounted payback (years) Benefit-cost ratio Net present value (average participant)
Ratepayer Impact Measure	
Lifecycle revenue impact per Unit of energy (kWh or therm) or demand customer (kW) Net present value	Annual revenue impact (by year, per kWh, kW, therm, or customer) First-year revenue impact (per kWh, kW, therm, or customer) Benefit-cost ratio
Total Resource Cost	
Net present value	Benefit-cost ratio (BCR) Levelized cost (cents or dollars per unit of energy or demand) Societal (NPV, BCR)
Program Administrator Cost	
Net present value	Benefit-cost ratio Levelized cost (cents or dollars per unit of energy or demand)

Source: World Bank, 2005.

GHG Emission Reduction Potential

Energy savings and reduced peak load demand from DSM programs help reduce GHG emissions to varying degrees, depending on the scale of the program and the electricity fuel mix. For example, a 2003 study of California's 218 DSM programs found first year energy savings of 4760 GWh and 3388 MW of demand savings. Likewise, California's DSM programs since 1977 have been estimated to have reduced air pollution emissions from stationary sources by 40% (NRDC 2003).

Cost-Effectiveness

The cost-effectiveness of DSM programs can vary by program, but California's successful example has shown that DSM can be very cost-effective with a lifetime cost of only 3 cents per kWh, or well below the lifetime cost of building new power generation (Global Energy Partners 2003). The U.S. DSM experience also had average upfront costs of 2 to 3 cents per kWh saved (NRDC 2003).

4.4.6.2. DSM Demand Response Programs

Policy Description

Demand response programs focus on energy saving strategies utilized during periods of peak demand, typically in hot weather months and during the afternoon hours. Demand response programs usually include price-based initiatives such as real-time pricing or critical peak pricing (see section 4.4.5) and incentive-based demand response initiatives where participating customers are paid to reduce their loads at requested times (e.g., peak hours). For incentive-based demand response programs, both participation and curtailment may be voluntary or mandatory. Additionally, most mandatory curtailment demand response programs feature direct load control where the utility can remote control equipment at the participant's site to reduce demand. Demand response programs have economic benefits for program participants and the electricity market, which can achieve increased capacity without new generation, and also improve the reliability and performance of the electricity system (Albadi and El-Saadany 2007).

Other incentive-based demand response programs include (CEC 2007):

- Load curtailment incentives where customers are paid a set rate per MWh curtailed when requested on a day-of basis
- Curtailable or interruptible rates where customers pay a lower rate by agreeing to mandatory curtailment or interruption when needed
- Direct load control of air conditioners and water heaters by utility for customers who receive a financial incentive
- Other bidding programs where customers bid and offer to curtail loads and serve as standby or replacement capacity for generation for utilities[46]

Performance Metric

Performance metrics include peak demand reduction and aggregate load reduction.

GHG Emission Reduction Potential

As with DSM energy efficiency programs, energy savings and reduced peak demand from demand response help reduce GHG emissions to varying degrees, depending on the scale of the program and the electricity fuel mix. In terms of the scale of peak demand reduction, the California Public Utilities Commission set a goal of achieving 5% peak demand reduction from demand response programs. In 2007, studies show that California achieved 1056 MW of peak demand reduction from price-responsive demand response programs and additional 1613 MW of peak demand reduction from interruptible, incentive-based demand response programs (CEC 2007).

Cost-Effectiveness

Demand response programs are generally cost-effective, with a study of North American utilities revealing that the benefits of demand response programs exceeded the cost by a factor of 7. Similarly, the New York utility programs paid out $27.2 in incentives to 14,000 participants to reduce 700MW peak capacity in 2003 with subsequent reliability benefits of more than $50 million (Albadi and El-Saadany 2007).

4.5. Agriculture, Forestry and Waste Management Actions

4.5.1. Afforestation of Rangeland

Policy Description

Afforestation of rangeland is the conversion of non-forest rangeland to forest land through planting, seeding or promotion of natural seed sources. This policy has been exemplified in California with a call

[46] Examples of these programs in California include ancillary services program, capacity market program and demand bidding/buy-back programs. More information on these programs can be found in CEC 2007.

to restore native tree cover on land that is currently covered with other vegetation or used for grazing. Specifically, a goal of reforesting 500,000 acres of forestlands by 2020 has been proposed (CAT 2006). Proposed sources of funding for the $30 million annual budget include bond funds, the establishment of a long term loan program, and market based programs.

Performance Metric

The performance metric for this program is the acres of rangeland restored with forests.

GHG Emission Reduction

Afforestation has high GHG emission reduction potential, with 150 to 230 tons of carbon captured per tree if harvested appropriately. The conversion of rangelands typically used for grazing into forests could theoretically sequester up to 5 billion metric tons of CO_2 over an 80 year time horizon (CAT 2006, CEC 2005). Environmental co-benefits include reduction in erosion and non-consumptive use of forests, such as for recreational uses.

Cost Effectiveness

Afforestation initiatives provides the most carbon at the least cost (⩽ $2.7/MT CO2)—about 33 MMTCO2 at 20 years to 4.57 billion MTCO2 at 80 years in California (CAT 2006, CEC 2005).

4.5.2. Manure Management

Policy Description

Manure management is an important agricultural policy for reducing non-CO_2 GHG emissions, particularly methane emissions from livestock. Manure management includes effective manure application practices, feed management practices, and use of storage, handling and treatment technologies to help minimize GHG emissions caused by microbial activities during manure decomposition (Government of Alberta 2010). Methane emissions, along with noxious odors, can also be reduced through the use of biogas digesters, which can also produce energy for heating or electricity applications. Manure management policies have been planned in California as part of AB32, the California Global Warming Solutions Act.

4.5.3. Conservation Tillage/Cover Crops

Policy Description

Conservation tillage uses cover crops to cover 30% or more of soil surface of cropland system to reduce soil erosion by water. Besides reducing erosion and improving soil quality and fertility, conservation tillage can also increase the amount of organic matter in the soil and thereby sequesters large amounts of carbon dioxide. The U.S. currently has a Farmers Union Carbon Credit Program where farmers are paid for using conservation tillage systems. California has also included conservation tillage using cover crops such as tomatoes, cotton, beans, and corn in its list of proposed early actions to mitigate climate change under AB32, the California Global Warming Solutions Act (CA EPA 2007).

Performance Metric

The performance metric for conservation tillage programs is the proportion of soil surface that is covered by crops.

GHG Emission Reduction Potential

In the U.S., conservation tillage practices could contribute to annual emission reductions of 13.3 $MtCO_2$ (Lal 2003). However, the overall reduction potential is relatively low with carbon sequestration rates of 0.35 to 0.61 $MTCO_2$ per hectare per year.

4.5.4. Increased Riparian Buffer

Policy Description

The maintenance and extension of natural buffers in the form of forests around riparian areas have many environmental co-benefits including catching eroded soil and preventing sedimentation, filtering nutrient runoff, buffering against floods and droughts and increasing carbon storage and sequestration in the trees. The promotion of riparian buffers is included California's AB32 and is generally promoted as a positive agroforestry practice.

Cost Effectiveness

Riparian buffers as a method for carbon sequestration has low-cost effectiveness with costs of between $2.7 and $13.6 per MT CO_2 sequestered (CEC 2005).

4.5.5. Longer Forestry Rotation

Policy Description

Increasing the rotation length of forests and extending the average harvest cycle by five years or more can increase carbon storage as well as provide other important environmental co-benefits and higher overall wood product yield. This practice is included in California's AB32 Global Warming Solutions Act plan.

Performance Metric

The performance metric of longer forestry rotations is the extended length of the harvest cycle.

4.5.6. Landfill Methane Capture

Policy Description

Landfill gases are a mixture of two important GHGs, methane and CO_2, and are released into the atmosphere if not captured. Landfill gases can be captured and burned through technology such as methane recovery systems and then either flared or used for energy production instead of being released into the atmosphere. Policies such as tax incentives and voluntary programs to promote landfill gas capture projects have been successful in the U.S. and methane recovery systems have already been implemented in California.

Performance Metric

The performance metric for landfill capture projects is the percentage of landfill gas, particularly methane, that is captured.

GHG Emission Reduction Potential

Further landfill gas capture actions under AB32 could achieve additional emission reductions of 30% (CAT 2006).

4.5.7. Recycling Goals

Policy Description

Related to landfill gas capture, another method of reducing landfill GHG emissions is by directly reducing the amount of landfill waste through setting ambitious recycling goals and targets. California, for example, set a goal under the Integrated Waste Management Act of 1989 to divert 50% of waste away from landfills and has been successful in achieving 48% waste diversion. AB32 calls for additional reduction in share of landfill waste with particular focus on promoting targeted commodity recycling programs in industry and public sectors with high GHG components (California EPA 2007).

Performance Metric

The performance metric for recycling goals is the relative level of the goal and the extent to which it is met.

Cost Effectiveness

Recycling goals have medium cost-effectiveness for reducing GHG emissions with costs of less than \$5.5 per ton CO_2e and average costs of under \$1 per ton CO_2e (CAT 2006).

4.5.8. Forest Management

Policy Description

Forest management techniques for carbon mitigation are focused on increasing stand-level forest carbon stocks and may include harvest systems that maintain partial forest cover, minimize losses of dead organic matter or soil carbon by reducing soil erosion and avoiding slash burning or other high emission activities (IPCC 2007). In the U.S., California has called for storing more carbon through forest management activities such as increasing the growth of trees, extending the overall age of trees prior to harvesting or dedicating more land to old growth trees. The state can play an important role in promoting forest management practices by simplifying the permitting process.

Performance Metric

The performance metric for forest management practices is the acres of forest on which forest management practices are in effect.

4.5.9. Forest Conservation and Preservation

Policy Description

Forest conservation focuses on preserving the amount of forestland and preventing further conversion of forestland to non-forested rangeland, thereby preserving the carbon stocks in trees. Forest conservation can be promoted through different policies and measures such as providing economic incentives to maintain undeveloped forest landscape.

Performance Metric

These policies can be measured by the acres of forestland preserved. Forest conservation and preservation also have many co-benefits such as biodiversity and habitat protection, maintaining water quality, and preserving recreational or aesthetic values of undeveloped forestland.

Cost Effectiveness

Forest conservation and preservation have low cost-effectiveness with high investment requirements on the order of $1 million annually to prevent the conversion of 14,000 acres of forestland (CAT 2006).

4.5.10. Urban Forestry Program

Policy Description

Urban Forestry Programs are programs that focus on planting trees in urban areas in order to increase carbon sequestration and also to benefit from indirect effects of reducing CO_2 emissions. Specifically, urban forests can reduce CO_2 emissions associated with electricity, natural gas, and fuel oil consumption in buildings because trees around buildings can reduce heating and air conditioning use (US Forest Service 2008). Policies to promote urban forests include setting up market mechanisms such as emissions trading and providing economic incentives for project developers to invest in urban forestry projects. In California, where a State Urban Forestry Program already exists, AB32 will expand the urban forestry program with a new goal of planting 5 million trees in urban areas by 2020 (CAT 2006).

Performance Metric

The performance metric for urban forestry projects is the number of trees planted in urban areas.

Cost Effectiveness

Urban forestry programs have low cost-effectiveness with high costs of $100 to plant a tree in urban area in California (CAT 2006).

4.5.11. Sustainable and Localized Food Production and Consumption

Policy Description

Since the production, distribution, processing, and consumption of food represents one of the largest sources of GHG emissions, promoting localized and sustainable methods of food production and consumption is a key way to reducing the ecological footprint of cities. In particular, the “sustainability” of food can be evaluated using different environmental and social criteria, including localized production and consumption (as defined by a geographical boundary), low carbon production, organic farming practices, good labor practices, healthy, affordability and certification (e.g., Fair Trade certified). Given these differing metrics of evaluating the sustainability of food, policies can be defined in terms of a carbon reduction target or more broadly in terms of local food infrastructure and proximity to fresh produce as is the case for Vancouver's new Climate Action Plan target (Vancouver 2010). States and cities throughout the U.S. have also adopted local food policies to promote localized and sustainable food production and consumption.

Specific policies can include (Vancouver 2010; Good Food LA 2011):

- supporting the creation of food infrastructure and food-related "green jobs" in food production, processing, storage, distribution, access and waste management
- supporting the compilation and dissemination of information on sustainable local food systems
- reducing long-distance distribution of food, as measured by the average transport distance of food from the time of production until it reaches the consumer (i.e., "food-miles")
- creating a designated food policy council to bring together stakeholders in evaluating the local food system
- establish a regional food hub to serve as wholesale exchange for local agriculture and expand the public's access to farmers' markets
- develop local and sustainable food procurement policies for the municipality and encourage food providers such as schools to participate
- streamline permits and approval processes for community gardens

Performance Metrics

Performance metrics for this policy include the number of community kitchens/farmers' markets/community gardens/food composting facilities/urban farms, proximity to retailers that sell fresh produce by population count, community's awareness of local food options, and food-miles.

GHG Emission Reduction Potential

Promoting local and sustainable agricultural practices can significantly reduce GHG emissions given that food production contributes to 83% of the average US household's 8.1 t CO_2e/yr footprint for food consumption. In particular, changing food consumption patterns can reduce emissions because certain food groups such as red meat and dairy products have up to 150% higher GHG intensity of production than a chicken, fish, or vegetable-based diet. Additionally, promoting local food consumption will also reduce the GHG emissions associated with food transportation, which average 6760 km in the U.S. from a life-cycle supply chain perspective (Weber and Matthews 2008).

4.6. Policies by GHG Reduction Impact and Cost Effectiveness

The previous sections compiled a list of key policies and measures that have been implemented successfully within China or globally. This information can serve as a policy menu for local governments to choose implementable policies to suite their situation. In the process, the impact of the policies and associated costs need to be evaluated in order to determine priorities. Although the sections discussed above provide estimated emission reductions and implementing costs for most of the policies where the data were available, they are mostly based on international experience, so the values may not be directly applicable to localities in China. More in-depth assessment and localized cost and impact analysis needs to be conducted in order to determine the saving potential and cost effectiveness of a specific policy.

Such savings potential and cost-effectiveness analyses are often used for technology deployment and cost curves are frequently generated to illustrate the estimates of the significance and cost of feasible abatement measures. However, the application of this approach to policies is more challenging as the savings and costs for a certain policy are often difficult to quantify. For example, the scope of the policy costs is often not clear (e.g., whether costs should include investment costs, government costs, program costs, or technology costs, and whether transaction costs should be included), calculation methodologies are not consistent among different analyses, indicators are not well developed, information on savings are often hard to obtain, and the savings and costs are highly dependent on a variety of factors such as the climate, local industrial structure, and energy price. As such, this report does not attempt to create a policy cost curve, but rather to provide basic indicators and methods of policy choice by categorizing policies into “High, “Med”, “Low” in terms of the savings and costs. Figures 15, 16, 17 and 18 provide such a categorization for policies in the buildings sector, industry sector, transportation sector, and power sector respectively. An example of a fully quantified cost and benefit analysis of adopting policies and practices is illustrated in Figure 19. This type of policy supply curve can provide local governments with helpful information for policy prioritization and implementation. To construct such a supply curve, however, would require more public datasets and survey results, and a more comprehensive and in-depth assessment.

Experience in developed countries demonstrates that end-use energy efficiency can reduce GHG emissions significantly at low cost. Many policy options reduce costs and allow for higher levels of deployment of energy efficient technologies and more energy-related service from the same or reduced energy use.

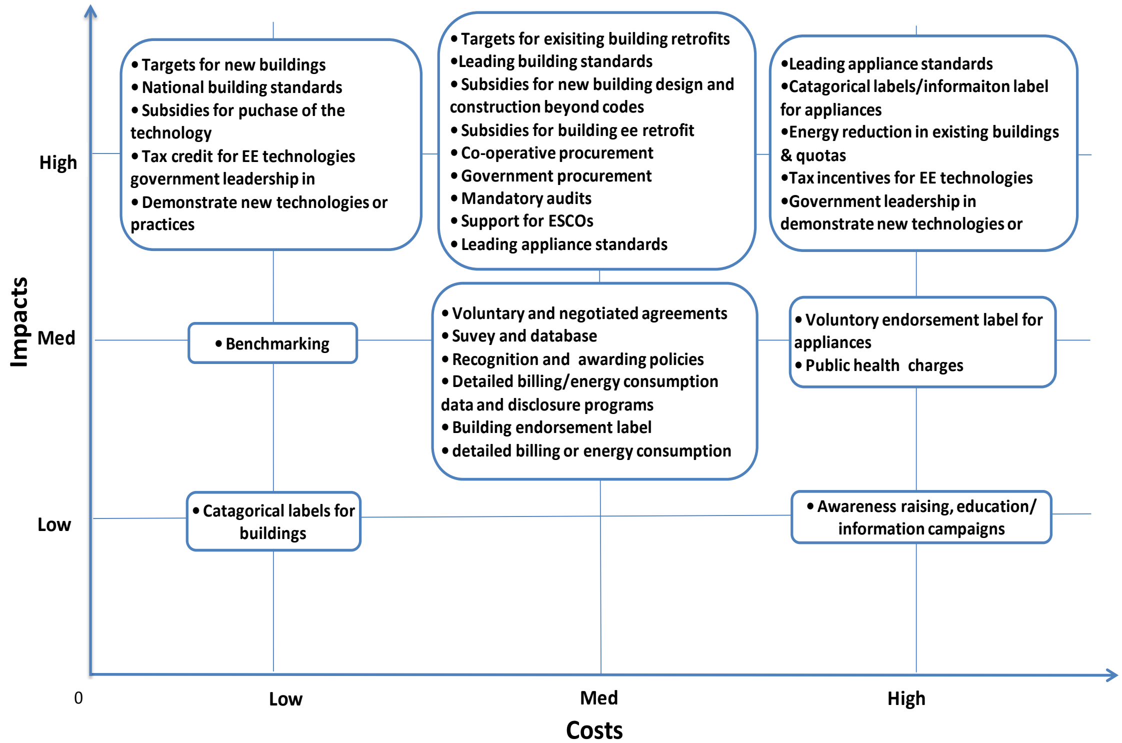

Figure 15 Cost and Saving of Energy Efficiency Policies in Buildings and Appliances

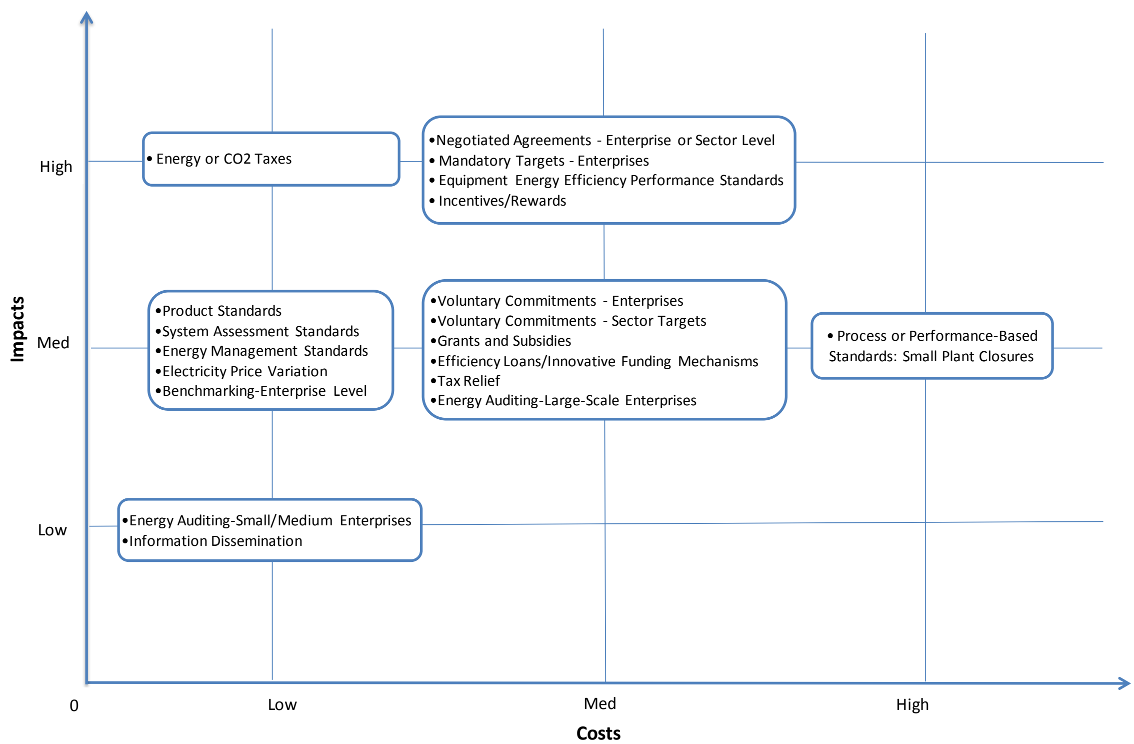

Figure 16 Cost and Saving of Energy Efficiency Policies in the Industry Sector

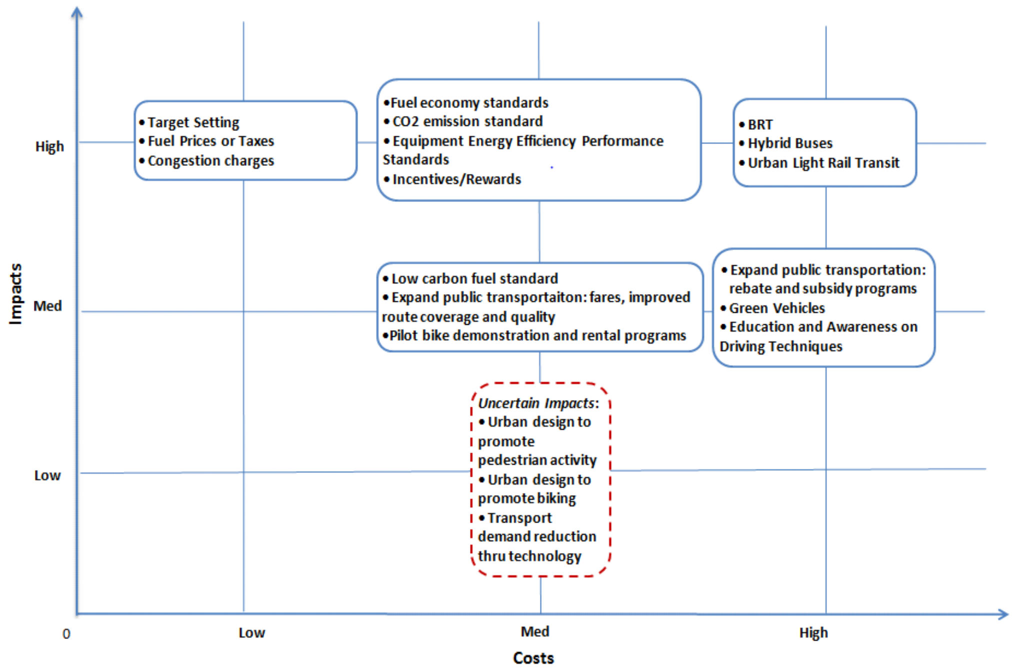

Figure 17 Cost and GHG Emission Reduction Impacts of Policies in the Transport Sector

Note: Boxes with dashed red border represent policies with impacts and/or costs with uncertainties and difficult to quantify.

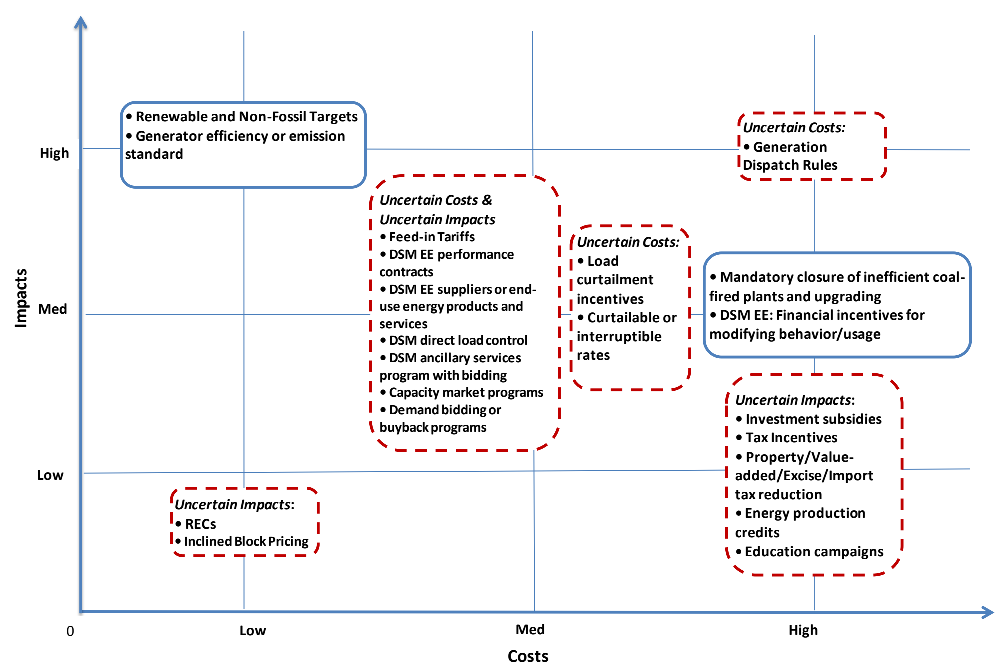

Figure 18 Cost and GHG Emission Reduction Impacts of Policies in the Power Sector

Note: Boxes with dashed red border represent policies with impacts and/or costs with uncertainties and difficult to quantify.

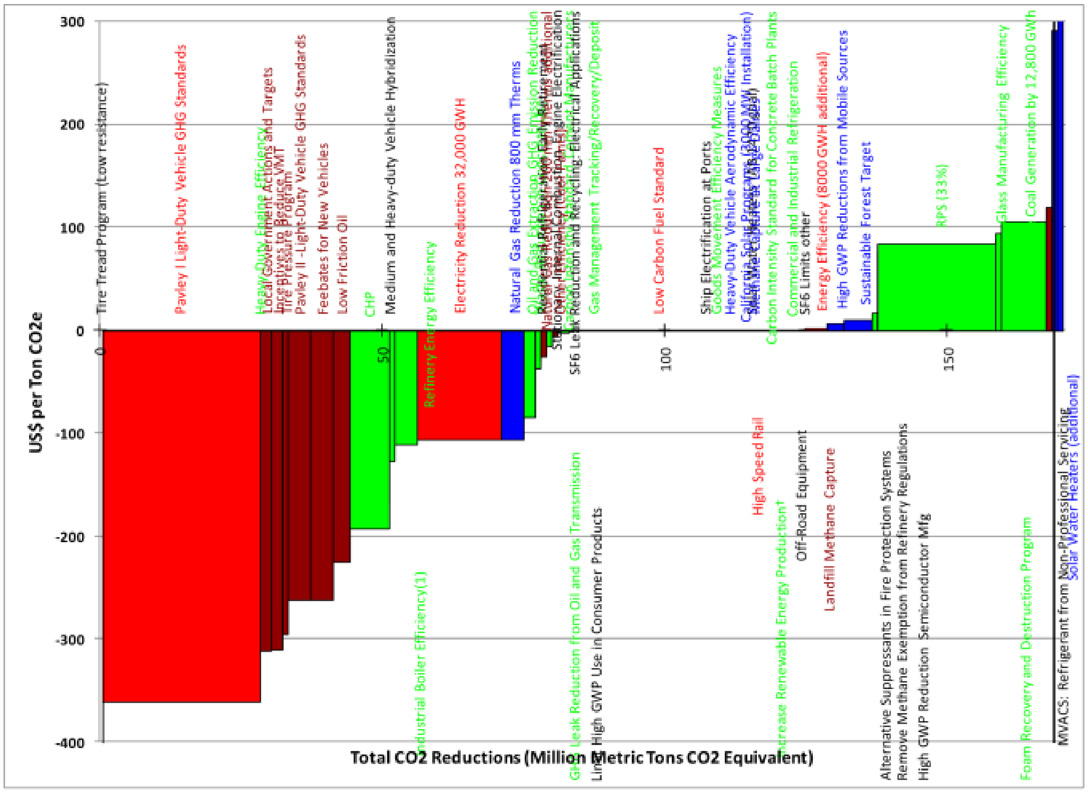

Figure 19 California Scoping Plan Marginal Abatement Cost Estimates[47]

Source: California EPA 2010.

4.7. Policy Benchmarking

For some policies or programs, benchmarking can be used to understand either the potential or actual policy impact. Benchmarking involves comparing current energy consumption or CO_2 emissions levels to the levels achieved under a given policy or program. Benchmarking can also be used to compare the achievements of different enterprises, cities, or provinces in response to a policy or program.

For example, a program to ensure achievement of the minimum energy-efficiency standards for industry could evaluate the potential savings from achievement of the standards, could identify the current

[47] Figures provide useful information, but are not a complete guide to the relative cost-effectiveness of the options shown. This is because the measure of "cost" in these figures does not capture two types of information highly relevant to the overall potential gains from these investments. First, while these figures capture the direct investment cost (e.g., the construction and maintenance costs of the investments), they do not include the cost of removing the applicable market barriers to these technologies. Second, the figures do not account for the external benefits associated with the investments. For example, they do not capture the environmental co-benefits stemming from reduced emissions of various local pollutants. Accounting for these benefits would add to the attractiveness of the investments displayed in the figures.

efficiency levels of specific enterprises, cities or provinces, and could track progress toward reaching the standards through benchmarking.

Figure 20 illustrates a method for comparing the level of achievement of the cement energy efficiency of standards by province. This figure illustrates the energy use per tonne of clinker (a key ingredient in cement) produced in each province. Horizontal lines provide the national minimum energy performance standards for existing clinker production facilities of three sizes (1000, 1000-2000, and 2000-4000 ton per day facilities) and for new clinker production facilities of 4000 tons per day or larger based on Chinese standards. Each province, then, can be benchmarked to these standards, indicating how much energy per tonne of clinker could be saved if all of the cement facilities in the province met the relevant standard levels. The central government can use this type of benchmarking to identify which provinces need the most assistance in achieving the standards. The figure also benchmarks the energy intensity of clinker production in each province to world best practice levels (Worrell et al. 2008). This type of benchmark could also be used to compare the stringency of the efficiency standard to international best practices and to set "reach" targets.

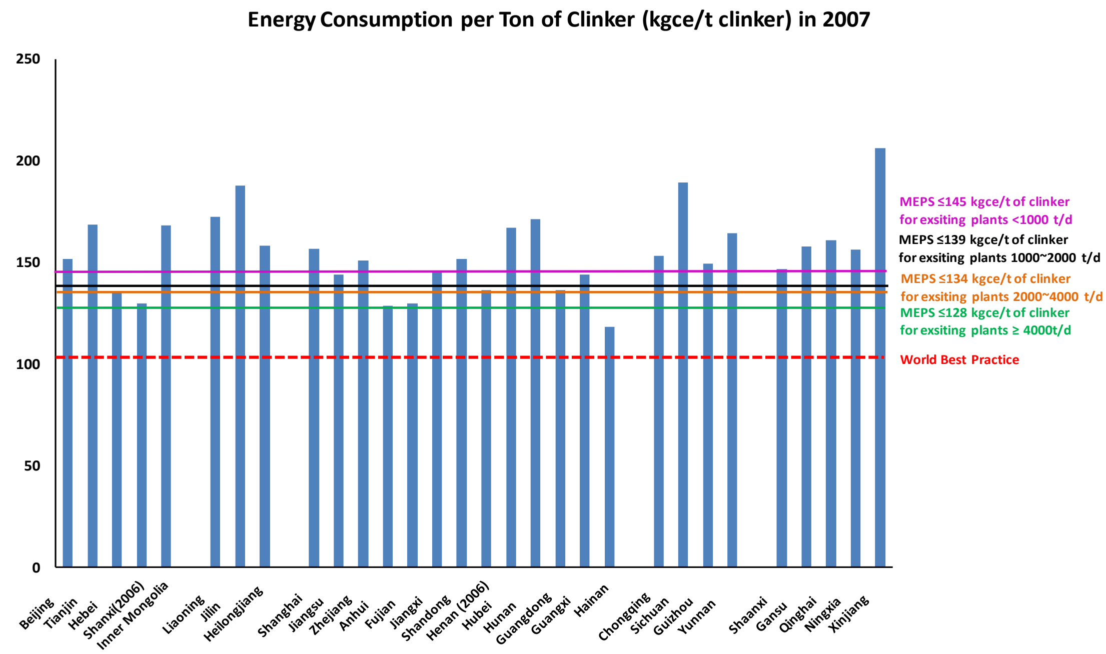

Figure 20. Benchmarking of Energy Intensity of the Cement Clinker Production in China[48]

Notes: MEPS = minimum energy performance standard

[48] Based on clinker energy use instead of cement energy use due to extensive clinker trade between provinces. Clinker energy use calculated by: 1) estimating the amount of clinker and additives ground by subtracting the clinker production from the cement production in the province, 2) subtracting 3.2 kgce/t clinker ground from the cement production energy consumption to derive clinker production energy consumption.

5. Tools and Case Studies of the Local Action Plans

Local Governments for Sustainability is an international association of local governments as well as national and regional local government organizations who have made a commitment to sustainable development. The International Council for Local Environmental Initiatives (ICLEI) was founded in 1990. The Council was established with more than 200 local governments from 43 countries, and now includes more than 600 local governments. ICLEI developed the Cities for Climate Protection (CCP) methodology to allow local governments to systematically estimate and track GHG emissions, as well as to develop climate action plans. The five milestone process is considered as one of the unique features of the CCP. Within this framework, following a political commitment statement of the representative of their local governments, participating cities are expected to:

- *Measure* their emissions of greenhouse gases, generated through the actions of their local government administration (government emissions) and through the actions of the community they serve (community emissions),
- *Commit* for an emissions (government or community) reduction target with respect to a base year and a target year,
- *Plan* their actions (e.g. energy efficiency in buildings and transport, introduction of renewable energy, sustainable waste management) at the government and community level to reach this committed reduction target,
- *Implement* their Local Climate Action Plan,
- *Monitor* emissions reductions achieved by their mitigation actions (ICLEI 2010)

ICLEI also provides guidebooks, toolkits, reports on Climate Action Planning, Sustainability Planning, Climate Adaptation Planning, Transportation and Land-Use Planning. The tools it developed includes: CACP Software 2009, Climate and Air Pollution Planning Assistant (CAPPA), Municipal Clean Energy Toolkit, ICLEI Data Collection Tools, ICLEI Consulting and Innovation, and a Green Building Decision Tool. Two tools developed by ICLEI that have been widely used to assist local governments in developing GHG inventories and climate action plans are:

Clean Air and Climate Protection (CACP) is a tool that estimates emissions (in terms of equivalent CO_2) derived from energy consumption and waste generation within a community based on the type of fuel used in specific sectors. The emission coefficients and methodology employed in the tool are consistent with national and international inventory standards established by the UN Intergovernmental Panel on Climate Change (IPCC 1996) and the U.S. Voluntary Greenhouse Gas Reporting Guidelines (EIA form 1605) (ICELI 2010). The tool has been used by over 200 U.S. cities and counties to reduce their emissions, and could do the following:

- Create emissions inventories for the community as a whole or for the government's internal operations.
- Quantify the effect of existing and proposed emissions reduction measures.
- Predict future emissions levels.
- Set reduction targets and track progress towards meeting those goals.

Climate and Air Pollution Planning Assistant (CAPPA) is a decision support tool ICLEI developed to help local government choose emissions reduction measures and develop climate action plans. CAPPA compares the relative benefit of a wide variety of emission reduction policies and measures and clean air measures, and helps identify the measures that are most likely to be successful for a locality based on its' priority and constrains. The tool itself consists of 110 emission reduction strategies in different sectors for local government in the areas of energy efficiency, energy generation, transportation, waste and others. This tool is most effective for use after a GHG inventory has been completed. It could be used subsequent to the use of CACP tool.

Other tools for building an emissions inventory and undertaking target setting include:

- Clean-Air Cool-Planet. Community Toolkit. http://www.cleanair-coolplanet.org/for_communities/toolkit_sitemap.php
- ICLEI USA. 2008. "Community Greenhouse Gas Inventory Methodology for Bay Area LocalGovernments." www.union-city.ca.us/green_city/Green_city_PDFs/GHG%20Methodology.pdf
- Natural Capitalism Solutions. "Climate Protection Manual." City Action Plans; State Action Plans. http://www.climatemanual.org/Cities/Chapter7/index.htm#splans

In 2005, the City of Cleveland, Ohio, created its Sustainability Program with the condition that the funding from the program comes from cost savings from energy efficiency and waste reduction. Between 2005 and 2007, the city conducted an assessment and auditing of key facilities such as buildings and waste treatment plants, and based on the auditing results, implemented various measures to improve the efficiency in building and the waste treatment plants, and implemented recycling program. The savings from shutting down a large, energy intensive dehumidification unit in the water treatment plant with no adverse effects were $160,000 over two years. In addition, the government operation recycling program has saved the city around $1 million over two years (ICLEI 2010).

In 2007, the City of Boston, MA, implemented a green building zoning code requiring privately owned and operated buildings that is more than 50,000 square feet throughout the city to reduce emissions from. The zoning code requires all major construction projects to meet the U.S. Green Building Council's LEED certification standard. The mayor put together a taskforce, and conducted comprehensive assessment of opportunities and challenges with green buildings in Boston, and provided recommendations. Based on the recommendations, a three year plan was created, and the city decided to change the city zoning codes instead of building codes because of the legislative structure. It was estimated that each building that adheres to its zoning code will save, on average, 82 tons of C02 and 64 million British thermal units per square foot of energy. As co-benefits, the Green buildings can also reduce energy imports and enhance worker productivity, as well as stimulate business growth and job creation (ICLEI, 2009).

Between May and November 2008, the city of Denver, CO, participated in a pilot test of the Driving Change program to promote "green" driving habits. 160 city vehicles and 240 citizen cars - including the mayor's car - joined a Vehicular Greenhouse Gas (GHG) Tracking System. The system compiled data on the car emissions and how different driving habits altered the missions including idling and rapid acceleration or braking, and relayed the information over the internet. The participants became more aware of their driving behaviors and began to drive more efficiently. As a result, idling was cut by more than 35%, emissions were reduced by 10%, and the fuel costs were also reduced (Driving Change 2011). The pilot program demonstrated that just changing driving behavior can result in emission reductions without breakthroughs in engine technology. The expansion of the program could help the city to meet its goal to reduce emissions to 10% below the 1990 level by 2011 (Driving Change 2011). The program also shows that educating people to monitor their emissions could motivate them to save more energy and reduce emissions.

In 2009, New York City mandated comprehensive and mandatory efforts to reduce emissions from large existing privately owned buildings in the city. This requires improvement in energy efficiency in buildings through building standards for retrofit or renovation, energy benchmarking and disclosure, mandatory lighting system upgrades and tenant sub-metering, and mandatory energy auditing, retro-commissioning, and retrofits (REEEP 2010).

6. Discussion & Conclusions

Much work lies ahead to appropriately define and implement low-carbon development at the city level in China. Although China has announced a goal to achieve lower carbon intensity and to develop low-carbon demonstration cities, there is still a strong need for methodologies, policies, programs, measures, indicators, and tools to achieve these goals. This guidebook provides an information resource for these efforts. The planning steps outlined in the guidebook can help cities shape a comprehensive effort and aim for climate-friendly city development. The policy options and categorization illustrated in this guidebook provide guidance for cities to take action.

Although beyond the scope of this guidebook, low-carbon indicators are also being examined and a new low-carbon indicator system with a ranking scheme has been developed in order to provide clear metrics for tracking energy and carbon savings over time, as well as comparing progress among cities (Price et al. 2011).

To date, the findings from the research have been presented in multiple workshops organized by China's central government as part of their low-carbon cities pilot project, as well as in training workshops for approximately 40 city mayors and practitioners in China. The participants were especially interested in the steps for development of a low-carbon plan and the policy matrix. Since the low carbon development plan was only introduced to Chinese policymakers over the last year, the current focus is on training and building capacity of Chinese local policymakers.

The interest of local Chinese governments in low carbon development is very recent (due to introduction of national policy in August 2010) and without specific policies and initiatives in place, it is not possible to measure how much the guidance has led to a reduction in GHG emissions. Without local GHG emission inventories, it will also be very difficult to measure reductions against a baseline.

As more attention is being paid to low-carbon cities and in response to China's national-level energy and carbon intensity reduction goals, many other cities or counties are also following the trend toward low-carbon development that is being initiated through the recently announced policy for establishment of low-carbon cities in China.

With the increasing interest from localities wanting to adopt the methodologies presented, the next step is the implementation of the steps outlined in the guidebook in selected cities. Based on the feedback and experience, the guidebook can be further improved and tailored to the Chinese situation and can be used by as many cities as possible in order to assist both the achievement of the carbon intensity goal and to ensure the successful implementation of the low-carbon city program.

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Appendix A: Co-benefits in California's Example

Various studies conducted as part of California's Climate plan shows that low carbon development has the following co-benefits:
The plan generates jobs, promotes a growing, clean-energy economy and a healthy environment for California at the same time.

California gets more clean energy venture capital investment than all states combined. In 2009, while other sectors saw little or no investment, the clean technology sector in California received $2.1 billion, 60% of the total in North America. Venture capital investments in the Golden State totaled nearly $6.6 billion from 2006 to 2008, about five times more than our nearest competitor, and more than all other states combined. *(Source: California Green Innovation Index, Next 10)*

Green technologies produce new jobs faster. Investments in green technologies produce jobs at a higher rate than investments in comparable conventional technologies. And the first beneficiaries of green job growth will be workers who are currently unemployed. *(Source: Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate, UC Berkeley, California Green: Opportunities and Challenges, Center for Continuing Study of the California Economy)*

Green jobs are growing faster than any other industry. From 2007 to 2008, jobs in green businesses grew 5% while total jobs in California fell 1%. The green economy could soon become the nation's fastest-growing job segment, accounting for roughly 10% of new jobs over the next 20 years – up to 4.2 million new green jobs – 500,000 in California. *(Source: Many Shades of Green: Diversity and Distribution of California's Green Jobs, Next 10, U.S. Metro Economies: Current and Potential Green Jobs in the U.S. Economy, U.S. Conference of Mayors)*

California leads the nation in every clean technology category. California entrepreneurs opened more green businesses (10,209), created more new jobs (125,390), and garnered the most clean energy venture capital funding ($6.5 billion) than any other state. *(Source: The Clean Energy Economy, Pew Charitable Trusts)*

The plan expands California's successful track record of saving money through efficiency.

Energy efficiency is the greatest energy resource. The state's energy efficiency policies have saved Californians $56 billion, and are expected to save another $23 billion over the next five years – money that is reinvested back into the California economy. *(Source: Energy Efficiency: California's Highest-Priority Resource, California Public Utilities Commission and California Energy Commission)*

Investment in greening existing buildings is good for business. By upgrading existing facilities to improve energy efficiency, businesses can save approximately 60 cents per square foot, reducing per-square-foot energy costs (currently $1.50 to $2.50) by as much as 40%. *(Source: Center for Energy & Climate Solutions)*

Energy efficiency saves consumers money. Under AB 32, homeowners can save about $200 per year through energy efficiency – savings between 1,500 and 1,800 kWh per year and over 300 therms of natural gas per year by improving energy efficiency by 25%. *(Source: Options for Energy Efficiency in Existing Buildings, California Energy Commission)*

3

Energy efficiency helps reduce the need for new power plants. For every dollar invested in improving energy efficiency, two dollars are saved by not having to build additional power plants and transmission facilities. *(Source: Energy Efficiency in the North American Existing Building Stock, International Energy Agency)*

Clean cars cost less to drive. Under California's cleaner car law (the Pavley greenhouse gas standards), consumers save on operating costs through reduced fuel use – an extra $30 each month for other expenditures. *(Source: ARB Final Statement of Reasons for Pavley Regulations, California Air Resources Board)*

The plan helps reduce risks that could be costly to California.

California's real estate assets are at risk. $2.5 trillion in real estate assets in California are at risk from extreme weather events, sea level rise, and wildfires, with a projected annual price tag of $300 million to $3.9 billion over this century, depending on how warm the world gets. *(Source: California Climate Risk and Response, David Roland-Holst and Fredrich Kahrl, UC Berkeley)*

Scarce water supplies could cost millions annually. Water supply costs due to scarcity and increased operating costs would increase as much as $689 million per year by 2050. Researchers found that changes in yields (mostly negative) and changes in water availability could result in gross revenue losses of up to $3 billion by 2050. *(Source: Climate Warming and Water Supply Management in California, Estimating the Economic Impacts of Agricultural Yield Related Changes for California)*

Costly wildfires will continue to increase. Scientists estimate that wildfire risk will increase throughout the end of the century. Average annual monetary impacts due to home loss may plausibly be on the order of $2 billion per year by mid-century and up to $14 billion per year by the end of the century. *(Source: Climate Change, Growth, and California Wildfire; Potential Effects of Climate Change on Residential Wildfire Risk in California)*

The plan relies on a strong network of climate partnerships – so California is not going it alone.

Local government will play an essential role in fighting climate change. More than 100 California cities and counties have signed the U.S. Conference of Mayors Climate Protection Agreement. Many have established offices of climate change and are developing and implementing comprehensive plans to reduce their carbon footprint. *(Source: U.S. Conference of Mayors)*

Many are participating in voluntary programs. Nearly 350 companies, municipalities, organizations and corporations are members of the California Climate Action Registry, reporting their greenhouse gas emissions on an annual basis. Californians have also been on the leading edge of purchasing offsets to mitigate their own personal emissions. The state intends to ensure our citizens that they can be assured of the credibility of these offsets. *(Source: California Climate Action Registry)*

Western states are building strong regional program. There are seven American states and four Canadian provinces that make up the Western Climate Initiative. The WCI is an historic effort to collaborate climate action policies of the western United States, Canada and Mexico. More than half of U.S. states have climate policies in various stages. *(Source: Western Climate Initiative)*
4

State government will lead by example. As an employer of more than 350,000 Californians, state government is uniquely situated to adopt and implement policies that give worker the ability to decrease their individual carbon impact, including encouraging transit use, telecommuting and use of alternative work schedules. *(Source: Climate Change Scoping Plan, California Air Resources Board)*

The plan promotes improved public health, lowers health care costs.

Public health benefits save billions. Preliminary analysis indicates that the total economic value associated with public health benefits is likely to be on the order of $4.3 billion in 2020. *(Source: Climate Change Scoping Plan, California Air Resources Board)*

AB 32 will significantly reduce harmful pollution. The estimated reduction of combustion-generated soot (PM 2.5) associated with the recommended regulatory measures is 15 tons per day. The estimated reduction of oxides of nitrogen (a precursor to smog) totals 61 tons per day. *(Source: Climate Change Scoping Plan, California Air Resources Board)*

Improved air quality promotes public health*.* These reductions in harmful air pollution lead to 770 fewer premature deaths and 76,000 fewer work days lost. *(Source: Climate Change Scoping Plan, California Air Resources Board)*

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